Illness Indicators in Lompoc, California

An Evaluation of Available Data

June 1998

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

ACKNOWLEDGMENTS

The following have contributed to this report; their help is greatly appreciated.

Amy Arcus
Jennifer Mann
Kiumarss Nasseri, Tri-Counties Regional Cancer Registry
California Birth Defects Monitoring Program

Illness Indicators in Lompoc, California

An Evaluation of Available Data

Prepared by:

Joy A. Wisniewski
Richard G. Ames
Robert Holtzer
Michael Lipsett
Anna M. Fan

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

June 1998

EXECUTIVE SUMMARY

An evaluation of available health data for Lompoc, California, was performed in response to a request from the California Department of Pesticide Regulation to "evaluate which illnesses in the Lompoc area are occurring at a higher rate than would normally be expected." This request to the Office of Environmental Health Hazard Assessment (OEHHA) was prompted by concerns expressed by some members of the community that Lompoc had an unhealthy environment brought about, in the residents' perception, by use of pesticides in agricultural areas located close to residential areas. Some Lompoc residents have complained of a broad spectrum of health problems, including (among many others) asthma, bronchitis, otitis (ear infections), and several types of cancers, as well as a wide range of non-specific symptoms, such as nausea, headache, and lethargy. In addition, some residents reported that infants and children were sick more often than adults, and females more often than males.

The purpose of this evaluation was to determine if certain illnesses were elevated in Lompoc compared to other areas in California. Illnesses were examined that predominated in the complaints received from Lompoc residents. Although this evaluation was not intended to be a comprehensive evaluation of the health status of Lompoc residents, it was a first step in verifying the health concerns raised by residents and in defining which illnesses may need further study. Moreover, the results of this evaluation would provide direction for future studies designed to examine causality since that was not the intent of this evaluation.

This evaluation was based on readily available sources of health data. Accordingly, several county- or state-maintained databases were identified from which data were obtained for analysis. These data include cancer incidence data for 1988 to 1995 from the California Cancer Registry (CCR); birth defects data for 1987 to 1989 from the California Birth Defects Monitoring Program (CBDMP); information on live births for 1988 to 1994 from the California Department of Health Services (DHS); and hospital discharge data for 1991 to 1994 from the Office of Statewide Health Planning and Development (OSHPD).

Of these databases, OEHHA found that the cancer incidence and hospital discharge data were most relevant for evaluating the health complaints of the Lompoc residents. Incidence rates of lung and bronchus cancers were significantly elevated in Lompoc compared to expected numbers based on regional incidence rates. This elevation was about 37% above the expected incidence and was statistically significant at the 99% level. The incidence rates for other cancers (i.e., stomach, liver, breast, brain and other central nervous system, thyroid, female genital, male genital, kidney, Hodgkin's disease, non-Hodgkin's lymphoma, multiple myeloma, and leukemia) were not significantly elevated.

The hospital discharge data analysis showed Lompoc to have elevated proportions of hospital discharges for bronchitis, asthma, and perinatal respiratory disease relative to the total of all non-birth or non-birth-related hospital discharges. This elevation showed up when Lompoc was compared to Santa Barbara County excluding Lompoc, Ventura, San

Luis Obispo, Mendocino, or Humboldt plus Del Norte counties. Bronchitis and asthma discharges were elevated approximately equally when the two discharge categories were analyzed separately by International Classification of Diseases (ICD-9) codes (for bronchitis, odds ratio (OR)=1.69, i.e., 69% increase, and for asthma OR=1.58, i.e., 58% increase). Bronchitis discharges were significantly elevated in the youngest and oldest age groups (<5 and ≥60 years old), while asthma discharges were significantly elevated only among adults older than 25 years. There was no difference between seasonal variation of Lompoc and seasonal variation of the comparison counties when bronchitis or asthma discharges were compared by admission quarter.

The excess proportion of hospital discharges for respiratory illness in Lompoc was not explained by age (although age was a partially confounding factor), sex, race/ethnicity, admission quarter (a measure of seasonal variation), or admission year, although the excess was greater in some years than others. The pattern of elevated respiratory discharges, which was demonstrated using multiple county comparisons, essentially was replicated in the individual county comparisons. A discriminant function analysis corroborated these findings by showing that residence in Lompoc was associated with elevated bronchitis and asthma discharges independent of age, race/ethnicity, sex, and admission quarter. An additional analysis comparing several nearby towns or towns located farther away but surrounded by agriculture to the five-county control area showed that Lompoc appears unique in having elevated proportions of hospital discharges for bronchitis, asthma, and perinatal respiratory disease.

Rates of seven common birth defects were not significantly increased in Lompoc nor were there any patterns among cases to suggest a common underlying cause. A review of the birth profiles indicated that more than 90% of babies born to mothers in Lompoc had normal birthweights and most mothers received prenatal care.

The four databases analyzed were considered the most appropriate for providing health-related and reliable information for the objectives at hand. Nevertheless, they are subject to many limitations. For cancer incidence, data on risk factors such as diet, smoking habits, or lifestyle, are not collected by the CCR; however, such factors may have a profound influence on the incidence and types of cancers observed in a population. Approximately 85% of lung cancers can be attributed to tobacco use; therefore information on smoking habits is critical to determining potential causes for the increased incidence of lung cancer in Lompoc.

Birth defects data specific for Lompoc (Zip Codes 93436 and 93438) were only available for 1987 to 1989, the years in which Santa Barbara County was included in the CBDMP. The conclusions reached by the CBDMP are based on a relatively small number of births (2,492) and have limited statistical power. Additionally, any changes in environmental conditions or birth defects patterns that might have occurred since 1989 cannot readily be analyzed due to lack of available data. When evaluated in conjunction with birth defects data, the birth profile data may offer additional insight into possible causes of birth anomalies (e.g., risk factors related to maternal age), although they do not provide definitive cause and effect relationships. However, analysis of these data did not reveal any useful information pertaining to the symptoms or illness complaints described to OEHHA staff by residents.

It is possible that the results obtained in the hospital discharge data analysis might partially be due to a statistical artifact; that is, some statistically significant findings can emerge by chance alone. OEHHA tried to address this possibility through the use of multiple statistical methods and reference groups, as well as multiple comparison areas. Since the same basic discharge patterns were identified using different analytical methods, we do not believe that false positive results are a likely explanation of our findings. Calculating incidence rates of hospital discharges would be a more direct approach to addressing the issue of increased illness in Lompoc. However, we were not able to obtain reliable population estimates for Lompoc for the years following the 1990 Census, and using the estimates we did obtain would have introduced an unknown source of error into the rate calculations, resulting in low confidence in the incidence rate estimates. Other aspects of the data analysis that we were unable to address with the available OSHPD database include differences in admission criteria applied by local physicians or insurance carriers, multiple admissions of patients for the same diagnosis, personal factors (e.g., occupational history, potential environmental exposures, dietary habits, tobacco use), and specific location of residence. Moreover, hospital admissions most likely cover more severe illnesses, whereas the majority of complaints received from residents were related to respiratory symptoms and other minor illnesses that would not require hospitalization. This analysis, therefore, could not fully address the issues relating to the health status of Lompoc residents.

Considering the limitations of the overall database available for evaluation, and notwithstanding the limitations of the hospital discharge data analysis itself, we found that the hospital discharge data analysis most directly addressed the objective of this evaluation–to determine if certain illnesses were elevated in Lompoc compared to other areas. The analysis was based upon a large sample size (647,290 hospital discharges), covered a four-year period (1991 through 1994), and used five counties as comparisons. Several methods of analysis were used, which provided similar results, increasing confidence in the interpretation of the data. The analysis focused upon physician diagnoses of illnesses, and the hospital discharge database is subject to extensive quality assurance, as it is maintained as an official record by the State of California.

This analysis shows elevated hospital discharges for respiratory illnesses and increased incidence rates for lung and bronchus cancers in Lompoc relative to comparison areas. Elevated respiratory illnesses are consistent with some of the community concerns that prompted this evaluation; however, this analysis did not address whether there were any specific cause(s) for the elevated illnesses. The findings of this report may be useful in determining the direction and scope of any future investigation, such as focusing on disease incidence, a wider range of illness severity (symptoms and mortality), and obtaining personal histories of residents, including occupational and other pertinent exposures, and tobacco use. Environmental correlates of residence in Lompoc, such as meteorological conditions, seasonal differences, and ambient environmental contaminants, should be investigated.

TABLE OF CONTENTS

I. HEALTH DATA EVALUATION

LIST OF FIGURES

LIST OF PATTERN ANALYSES

LIST OF TABLES

II. APPENDICES

INTRODUCTION

Since late 1993, the Santa Barbara County Agricultural Commissioner's Office has received complaints regarding pesticide usage near the town of Lompoc, California (Akers et al., 1995). Some residents expressed concern that they were experiencing illnesses and various health symptoms that they attributed to pesticide exposure. To address these concerns, the Department of Pesticide Regulation (DPR) of the California Environmental Protection Agency (Cal/EPA) began working with the Santa Barbara County Agricultural Commissioner, the Santa Barbara County Health Department, and area residents and growers to examine pesticide usage and application techniques in the Lompoc Valley. The report, "An Inventory of Pest Management Practices in the Lompoc Valley" (Akers et al., 1995), was the result of this effort. Additionally, the California Air Resources Board (ARB) and the Santa Barbara County Air Pollution Control District conducted PM_{10} monitoring for particulate matter at the Clarence Ruth School on the western side of Lompoc from June 1995 to May 1996 to determine if the levels of dust or other particulate matter in town were above the 24-hour state PM_{10} Ambient Air Quality Standard of 50 $\mu g/m^3$. ARB did not find any levels exceeding existing air quality standards (DPR, 1996).

In October 1994, DPR asked Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA) for assistance in assessing the health status of the community. The specific request was for an evaluation of "which illnesses in the Lompoc area are occurring at a higher rate than would normally be expected." DPR stated, "Such an evaluation would provide the community with much needed information on the relative health of the community." DPR did not ask OEHHA to find a cause or causes for the illnesses, but only to identify which illnesses may be problematic in the Lompoc area (Memorandum from P. Gosselin, DPR, to A. Fan, OEHHA, dated October 26, 1994). This evaluation of cancer incidence, birth defects, birth profiles, and hospital discharges is in response to DPR's request to assess the extent of health problems in Lompoc.

BACKGROUND

Lompoc is a small city located in Santa Barbara County along California's central coast. In the 1990 U.S. Census, Lompoc had a population of 37,649. Lompoc has unique topography and environmental characteristics. Approximately seven miles of extremely flat agricultural land separate the city from the Pacific Ocean (Figure 1). Hills on the north and south sides of the Lompoc Valley fan out in a "V" shape toward the ocean so that wind blown over the farmland channels over the city. Hills to the east of Lompoc

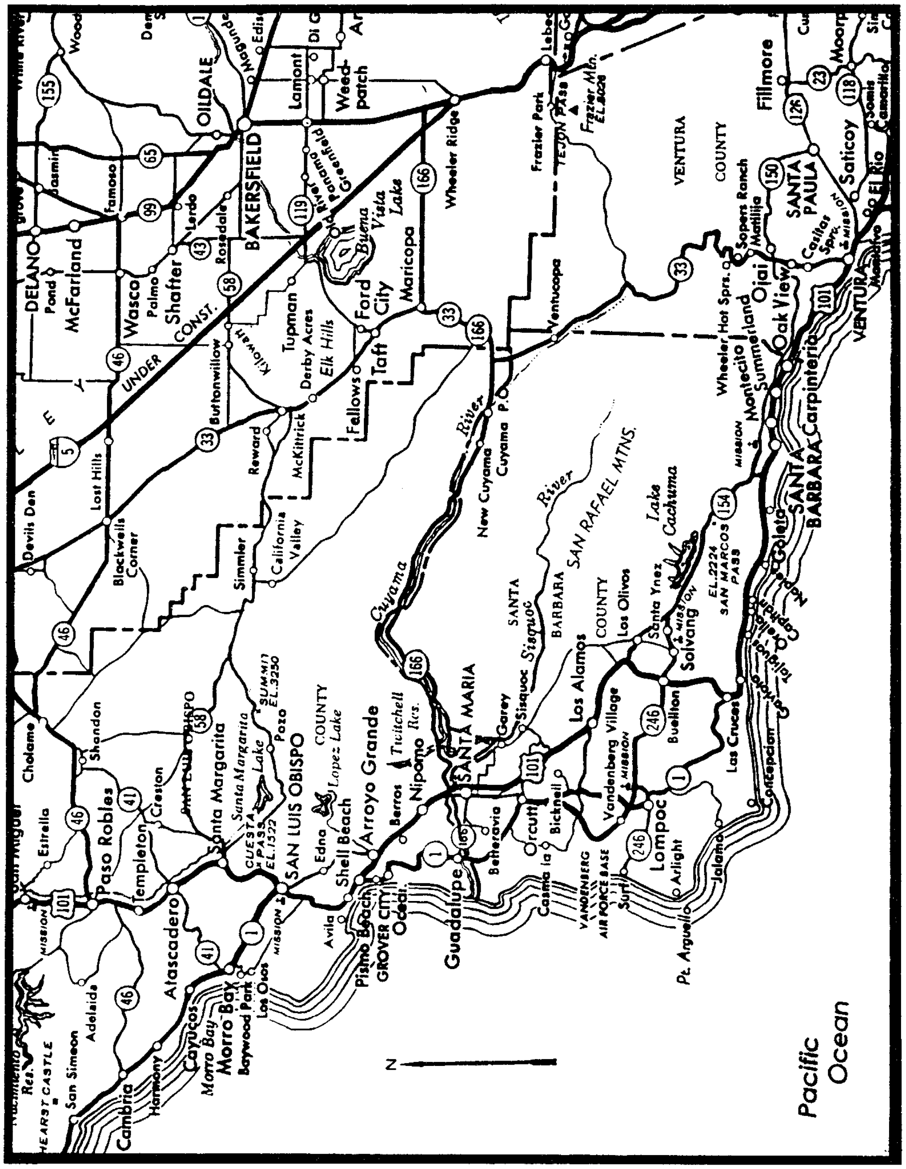

Figure 1. Map of Lompoc, California, and Surrounding Areas

tend to stall air movement over the town. Residents report that fog and thermal inversions are common. Unique vegetation, Burton Mesa chaparral, is found in the area (Hickson, 1987; Philbrick and Odion, 1988). Some vegetation has the potential to offgass volatile oils. Two large federal facilities are adjacent to the town: the Lompoc Federal Penitentiary; and Vandenberg Air Force Base, a missile facility. Extensive diatomaceous earth mining operations take place near the coast, and a diatomaceous earth processing plant with a tall smokestack and visible effluent is located on the east side of town. Lompoc has a history of agriculture, but a recent trend is a reduction in commercial flowers and an increase in production agriculture, especially vegetables and row crops. Lompoc also has developed into a commuting suburb of the city of Santa Barbara.

OEHHA staff met with several Lompoc residents in July 1995 to document their symptoms first-hand. Meetings were held individually and in groups. The predominant symptoms or illnesses reported were respiratory in nature, such as asthma, bronchitis, frequent colds, sinus congestion, coughing, sneezing, and rhinitis, but also included nonspecific symptoms, such as nausea, headache, and lethargy. Several parents reported that children had repeated ear infections, and that many had been provided with ear tubes. Symptoms or illnesses less commonly reported included vomiting, hair loss, skin rashes, blurred vision, muscle cramping, various types of cancer (pancreatic, brain, leukemia), lupus erythematosus, amyotrophic lateral sclerosis, Parkinson’s disease, Meniere’s disease, and spasmodic dysphoria. In addition, several residents reported that infants and children were sick more often than adults, and females more often than males.

PURPOSE AND OBJECTIVES

The purpose of this evaluation was to determine if certain illnesses were elevated in the Lompoc area compared to other areas in California. Only specific illnesses were examined, primarily those that predominated in the complaints received from Lompoc residents. This study was not intended to be a comprehensive evaluation of the health status of Lompoc residents, nor was it intended to examine causality for any observed increases in illnesses because this was outside the request from DPR. However, the evaluation was a first step in verifying the health concerns raised by residents and in defining which illnesses may need further study. Furthermore, this evaluation would provide direction for future studies designed to examine causality.

The data for this evaluation were obtained from county- or state-maintained databases. These databases were easily accessible and reliable. The report includes an analysis of cancer incidence data from 1988 to 1995, a report of birth defects in Lompoc from 1987 to 1989, information on live births in the Lompoc area from 1988 to 1994, and an analysis of hospital discharge data from Lompoc from 1991 to 1994.

CANCER INCIDENCE

Methods

The California Cancer Registry (CCR), a component of the Cancer Surveillance Section of the California Department of Health Services (DHS), has collected data on cancer incidence from participating hospitals since 1947. Since January 1988, under the Statewide Cancer Reporting Law, the CCR has covered the entire population of California through ten regional population-based registries. The Tri-Counties Regional Cancer Registry (TCRCR), covering Santa Barbara, San Luis Obispo and Ventura counties, is one of these regional agencies (Region 4).

Medical facilities providing therapy to cancer patients and medical practitioners diagnosing or treating cancer patients are required to report designated cancer cases within six months after admission and/or diagnosis. Reported information includes patient data (for example, age, sex, race/ethnicity), type of cancer, method of diagnosis and treatment, and place of residence at the time of diagnosis. The patient's address at diagnosis is coded to the appropriate census tract, which is a division of the county for which detailed population data are available. This information is kept in strict confidentiality and is used for monitoring the incidence of cancer, patterns of diagnosis and treatment, and other scientific research. Evaluation of allegedly high numbers of cancers in a geographic area (i.e., possible cancer clusters) is an example of the use of cancer reporting data.

OEHHA requested the TCRCR to determine whether an excess of cancer cases had been reported in the city of Lompoc. The city limits were defined by the census tracts 27.02, 27.03, 27.05, 27.06, 27.07, 27.08, 28.02, 28.06, and 28.07 (Figure 2). Cancer incidence was evaluated for the years 1988 to 1995, the time period for which reliable data were available.

OEHHA requested that the TCRCR evaluate cancers at all anatomical sites grouped together, as well as specific cancer sites. The CCR database only includes *invasive* cancers; it excludes *in situ*, or localized tumors, and basal and squamous cell lesions of the skin. The specific cancer sites were stomach, liver, lung and bronchus, breast, brain and other central nervous system, thyroid, female genital, male genital, and kidney, as well as cancers of the blood and lymphatic system, including Hodgkin's disease, non-Hodgkin's lymphoma, multiple myeloma, and leukemia. These cancers were selected for comparison for one or more of the following reasons: (1) they were perceived by the Lompoc residents as being elevated in the town (i.e., brain, thyroid, and leukemia), (2) they have been reported in the scientific literature as possibly related to agricultural lifestyles (i.e., leukemia [Brown et al., 1990]; Hodgkin's disease [Pearce and Reif, 1990]; non-Hodgkin's lymphoma [Cantor et al., 1992; Weisenburger, 1990; Zahm et al., 1990]; multiple myeloma [Brown et al., 1993]), or (3) they are sufficiently common (American Cancer Society, 1993) that OEHHA and the TCRCR determined that they would be appropriate to examine (i.e., lung and bronchus, breast, liver, stomach, kidney, genital).

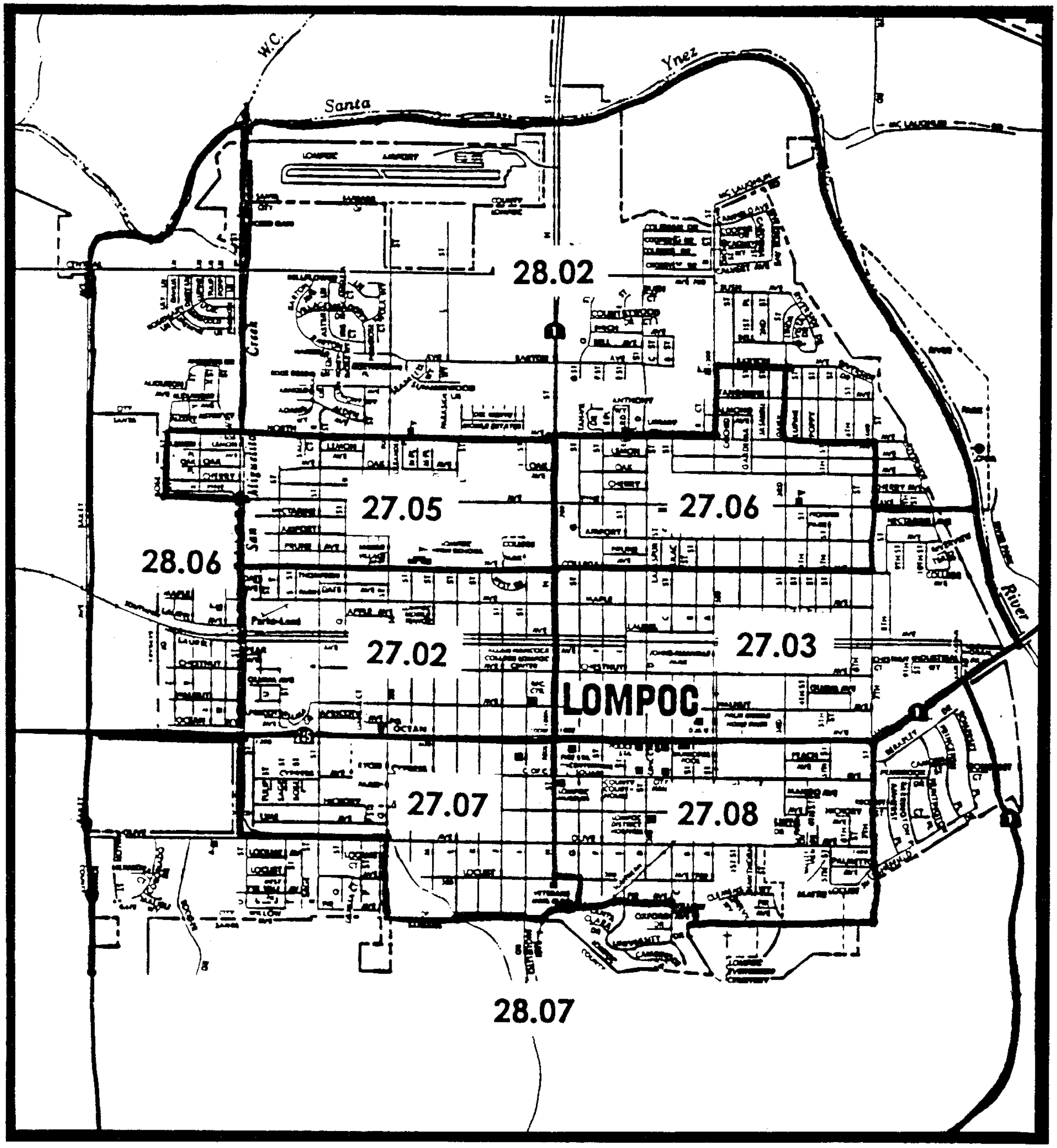

Figure 2. Map of Lompoc with Census Tracts

To evaluate possible excesses in cancer cases, the observed numbers of cases in Lompoc were compared to the expected numbers based on the regional incidence rates. The TCRCR first estimated expected numbers of cancer cases for 1990. They applied the 1988-1992 average annual age-, sex-, and race-specific rates for the Tri-Counties Region (San Luis Obispo, Santa Barbara and Ventura counties) to the population of the requested census tracts as estimated by the 1990 U.S. Census. The expected numbers for 1990 were multiplied by eight to provide the expected numbers for 1988 to 1995. The 99% confidence interval around the observed number was calculated based on the Poisson distribution, which is the standard procedure followed by the CCR and the TCRCR. The observed and expected numbers were then compared. If the expected number fell within the range of the 99% confidence interval, it was considered not statistically significant.

Table 1. Observed/Expected Analysis of Selected Cancer Sites for Lompoc, California, 1988-1995[a]

	1990	1988-1995			99% Confidence
Cancer Site/Group	**Expected**	**Expected[b]**	**Observed**	**SIR[c]**	**Interval[d]**
Stomach	2.113	16.904	15	0.89	6.89-28.16
Liver	0.754	6.032	9	1.49	3.13-20.00
Lung and bronchus	16.711	133.688	183	1.37	150.03-220.82
Lung and bronchus, male	9.258	74.064	100	1.35	76.12-128.76
Lung and bronchus, female	7.453	59.624	83	1.39	61.51-109.48
Breast, female	18.179	145.432	149	1.03	119.44-183.42
Brain and other CNS[e]	2.001	16.008	15	0.94	6.89-28.16
Thyroid	2.059	16.472	10	0.61	3.72-21.40
Hodgkin’s disease	0.925	7.400	4	0.54	0.67-12.59
Non-Hodgkin lymphoma	4.091	32.728	36	1.10	22.42-54.54
Multiple myeloma	1.189	9.512	13	1.37	5.58-25.50
Kidney and renal pelvis	2.663	21.304	34	1.60	20.857-52.107
All leukemia combined	3.204	25.632	25	0.98	14.00-41.00
Male reproductive organs[f]	18.945	151.560	128	0.85	100.737-160.130
Female reproductive organs[g]	8.504	68.032	82	1.21	60.553-108.340
All sites combined	116.687	933.496	1022	1.09	941.53-1107.26
All sites combined, excl. Lung	99.976	799.808	839	1.05	766.27-916.53

[a] Cancer incidence data were provided by the Tri-Counties Regional Cancer Registry.
[b] Expected numbers (1988-1995) = expected numbers (1990) $\times$ 8.
[c] SIR: Standardized Incidence Ratio. SIR = (Observed cases 1988-1995)/(Expected cases 1988-1995).
[d] Exact Poisson Confidence Interval around the observed numbers. If the expected number is within the range of confidence interval, it is considered that the difference between the observed and expected is not significant.
[e] CNS: Central Nervous System.
[f] Male reproductive organs include prostate, testis, and penis.
[g] Female reproductive organs include cervix, uterus, ovary, vagina, and vulva.
Note: A list of ICD codes that correspond to the cancer site descriptions can be found in Appendix A.

Results

Cancer incidence rates are provided in Table 1. The TCRCR concluded that the incidence of lung and bronchus cancers for the years 1988 to 1995 was significantly elevated in the Lompoc area. This increase was about 37% above the expected incidence. Incidence for all cancer sites combined also was significantly increased, but when lung and bronchus cancers were removed, the observed increase was no longer significant (see Appendix A).

Discussion

The evaluation for cancer incidence rates was based on data available from the CCR. At the time of OEHHA's request, the registry database was complete up to the year 1994, and only about 87% complete for 1995 (Appendix A). Therefore, the observed number of cases for 1995 could be underestimated by about 10% (i.e., 12 cases). Population estimates are based on extrapolations from the 1990 census and, therefore, only approximate the population over the eight-year period from 1988 to 1995, which may result in underestimation of the expected numbers. In addition, the Registry includes only the residential address at the time of diagnosis (i.e., does not include people who have moved out of the area prior to diagnosis) and does not include the duration of residence at that address. Most types of cancer, especially in adults, are believed to take years to decades between the onset of the malignant process and the first clinical evidence of the disease. Therefore, residential histories may be important to include in the analysis if environmental exposures to cancer-causing agents are of concern. For example, if a tumor begins to develop while a resident lives in a given area and the resident leaves the area before the onset of evident disease, there is little possibility of relating the cancer to local environmental factors. Similarly, a recent arrival who has subclinical cancer may be diagnosed after arrival. The latter cancer would have little or no relationship to the new residence location. Residence information may be of particular importance if there are substantial numbers of retirees and/or migrant workers who have moved into the area.

Data on age, sex, and race/ethnicity are routinely included in the CCR databases. Occupational information is important for determining possible exposures to cancer-causing chemicals or agents, and is collected by CCR when available. Data on other risk factors, such as diet, smoking habits or lifestyle, are not collected by the CCR; however, such factors may have a profound influence on the incidence and types of cancers observed in a given population.

The analysis of TCRCR data showed that the incidence of lung and bronchus cancers in the Lompoc area was significantly elevated in relation to that of the Tri-Counties Region during the period 1988 to 1995. Apart from nonmelanoma skin cancer, lung cancer is the most common cancer in the world. It is the leading cause of cancer deaths in the U.S. and California in both men and women. Five-year survival rates have improved little compared with other invasive cancers: during the 1980s such rates ranged from 10% in African-American men to about 16% for white women (Ernster et al., 1994). Active cigarette smoking accounts for about 85% of all lung cancers; nonsmokers exposed to their spouses' cigarette smoke experience an increase in lung cancer risk of about 30% (OEHHA, 1997). Numerous occupational respiratory exposures have been established as causes of human lung cancer, including asbestos, various metals (arsenic, hexavalent chromium, and nickel), radon, and chloromethyl ether, among others (Churg, 1994). Heavy occupational exposures to crystalline silica have been associated with an increased risk of lung cancer, particularly in workers who have developed silicosis (Goldsmith, 1994). Increased risks of lung cancers related to silica exposure were demonstrated in workers in the diatomaceous earth mining and processing facilities in Lompoc, but only in workers hired before 1960, as workplace exposures have declined substantially in recent decades (Checkoway et al., 1993; 1997). Genetic and dietary influences also affect an individual's risk of developing lung cancer. Exposures to ambient air pollution may result in a small increase in the risk of lung cancer, but study results have been inconsistent, perhaps because the increase in the risk conferred is small in comparison with other exposures, particularly cigarette smoking and occupational exposures.

Because OEHHA did not investigate causality, nor was that the purpose of this evaluation, we can only speculate as to why the incidence of lung and bronchus cancer was increased. We recommend that the incidence of lung and bronchus cancer in Lompoc continue to be monitored and that the influences of known causative factors, particularly tobacco smoking, be investigated. In addition, TCRCR staff members have suggested that it might be useful to evaluate the frequency of other smoking-related cancers and the educational levels of the population in the census tracts of Lompoc, since cigarette smoking varies by educational levels, and educational levels may provide a possible indirect measure of smoking prevalence (Appendix A).

BIRTH DEFECTS AND BIRTH PROFILES

Methods

Two sets of birth-related health data were available–birth defects and birth profiles. These data were evaluated because many of the Lompoc residents were concerned about the health of infants and children in the town, in particular, that they appeared to be more sensitive or susceptible than adults to health problems in Lompoc. In California, birth defects are monitored by the California Birth Defects Monitoring Program (CBDMP), which is funded by DHS. CBDMP includes data on structural defects, such as missing limbs and malformed hearts, birth defects patterns like fetal alcohol syndrome, and chromosome abnormalities (Stierman, 1994). It does not include information on metabolic or inherited diseases, such as cystic fibrosis or sickle cell anemia, functional problems without obvious structural defects, such as mental retardation, or poor pregnancy outcomes, such as low birth weight. The registry extended state-wide in 1990, but since then resource constraints have reduced the registry area. Currently, the CBDMP only serves Fresno, Kern, Kings, Los Angeles, Madera, Merced, San Francisco, San Joaquin, Santa Clara, Stanislaus, and Tulare counties.

Data specific to the Lompoc area (defined as Zip Codes 93436 and 93438) were available only for the years 1987 to 1989. Birth defects data for small areas, such as

Lompoc, typically are not provided by the registry because of the need to guarantee patient confidentiality, as well as the difficulty in interpreting the data, i.e., lack of statistical power because of the small number of births, demographic differences, and lack of exposure information. However, CBDMP recently developed a protocol to evaluate data on smaller communities and did such an evaluation of data specific for Lompoc (Appendix B). Birth defects rates in Lompoc were compared to Santa Barbara County and registry-wide rates for the period 1987 to 1989. The following seven common birth defects were examined: heart defects, chromosome abnormalities, pyloric stenosis, oral clefts, limb defects, neural tube defects, and intestinal atresias.

OEHHA obtained birth profile data from the Health Data and Statistics Branch of DHS, which prepares annual reports entitled "Birth Profiles By County and Zip Code." These reports contain information on maternal age, maternal race/ethnicity, trimester of first prenatal care, and birth weight of live infants abstracted from birth certificates. OEHHA extracted data for the years 1988 to 1994 for the State of California as a whole, Santa Barbara County, San Luis Obispo County and the city of Lompoc. In the database, maternal age was categorized by age groups of: less than 20, 20 to 29, 30 to 34, and 35+ years. Information on race/ethnicity was categorized by: Native American, Asian/Pacific, Filipino, Black, Hispanic, and White. Because of the small numbers of births to Asian/Pacific and Filipino women during 1988 to 1994, these two categories were combined for this report. Infants' birth weights were grouped as follows: normal (2,500 grams or more, or 5.5 pounds or more); low birth weight (1,500 to 2,499 grams, or 3.3 to 5.4 pounds); and very low birth weight (less than 1,500 grams, or less than 3.3 pounds). The data from the birth profile records were tabulated for visual comparison; however, statistical evaluations were not performed.

Results

Birth Defects

From 1987 to 1989, there were 40 infants with birth defects among the 2,492 live births and fetal deaths to Lompoc residents in Zip Codes 93436 and 93438. This corresponds to a rate of about 16.1 per 1,000 births. CBDMP's findings indicated that there was no significant increase in the overall birth defect rate in Lompoc or in the rates for the seven above-noted congenital anomalies, nor were there any patterns among cases to suggest a common underlying cause (see Appendix B).

Birth Profiles

Maternal Age

Information on maternal age by year and location is presented in Appendix B (Table B-1). Lompoc had a modestly greater percentage increase in younger mothers (<20 years) compared to Santa Barbara or San Luis Obispo counties or the entire state. There is a general trend in Lompoc and in the comparison areas toward increasing proportions of live births to women under 20 years and 35 years or older, which are the ages considered to be at higher risk for birth defects (Stierman, 1994). San Luis Obispo County was an exception, in that the percentages of younger mothers were relatively unchanged from 1988 to 1994.

Maternal Race/Ethnicity

Information on maternal race/ethnicity by year and location is presented in Appendix B (Table B-2). The most striking changes in maternal race/ethnicity over the 1988-1994 period were the substantial increases in proportions of births to Hispanic women in each of the four areas. There was a corresponding decrease in births to white women over this same period. Births to Hispanic women have accounted for the majority of births statewide since 1991. The percent change in births from 1988 to 1994 for Native Americans, Asian/ Pacific/Filipinos, or Blacks generally was about 1% or less.

Trimester of First Prenatal Care

The trimester of first prenatal care is considered important in the promotion of perinatal health, making first trimester care desirable for all expectant mothers. From 1988 to 1994, first trimester prenatal care occurred for 70% or more of live births in the selected areas (Appendix B, Table B-3). Another 14% to 23% obtained care in the second trimester. Six percent or less of live births had third-trimester institution of prenatal care. Approximately 1% or less mothers received no prenatal care.

Birth Weight

Birth weights for each of the four areas are presented in Appendix B (Table B-4). Very low birth weight infants account for only about 1% of live births. This proportion appears essentially unchanged over the 1988-1994 period for the selected areas. Infants with low birth weights account for about 3.5% to 5% of live births. In general, Lompoc, and Santa Barbara and San Luis Obispo counties had fewer low birth weight babies than the state as a whole for the 1988-1994 period. There was no apparent trend over the seven-year period in any of the birth weight categories when Lompoc was compared to Santa Barbara or San Luis Obispo counties.

Ninety-four percent or more of live births in the selected locations exceeded 2,500 grams (5.5 pounds). Lompoc, and Santa Barbara and San Luis Obispo counties slightly exceeded the state average for percentage of normal birth weight babies for the 1988-1994 period.

Discussion

Approximately 1 in 33 (3%) babies in California is born with serious structural birth defects (Stierman, 1994). There is some regional variation in the occurrence of birth defects, with the highest overall rate along the Mexican border and the lowest rates along the central/southern coast, which includes Santa Barbara County (Stierman, 1994). From 1987 to 1989, Santa Barbara County experienced a birth defects rate of 21.4 cases per 1,000 live births and fetal deaths, which is below that of the registry-wide average of 30.5 cases per 1,000 live births and fetal deaths (CBDMP, 1996). CBDMP's evaluation found that the available data do not indicate there were any increases in or patterns of birth defects in Lompoc from 1987 to 1989, the years that Santa Barbara County was included in the registry. Any changes in environmental conditions or birth defects patterns that might conceivably have occurred since 1989 are not readily analyzed due to lack of available data. CBDMP's conclusions are based on a relatively small number of births and have limited statistical power. Also, variations in demographics or medical practice can influence rates, complicating comparison to other areas (see Appendix B).

OEHHA examined birth profile data to determine if birth outcomes in the Lompoc area were different from surrounding areas, i.e., Santa Barbara and San Luis Obispo counties and California as a whole. Most areas demonstrated an increase in mothers under 20 years and over 35 years of age during the 1988 to 1994 period. Lompoc showed greater percentage increases for mothers less than 20 years old than the other areas. Although babies born to mothers under 20 and over 35 years have been reported to have slightly higher birth defect rates than those born to mothers in the 20 to 34 year age range (Stierman, 1994), the present analysis does not allow assessment of maternal age effect.

There have been striking changes in maternal race/ethnicity during the 1988-1994 period. In the majority of the compared areas, births to mothers identified as Hispanic have predominated since 1991. Maternal race/ethnicity has implications for newborn health in that there are notable race/ethnicity differences in rates of specific birth defects (Stierman, 1994). However, as mentioned previously, the small number of births for the years Lompoc was included in the CBDMP precluded any evaluation of race/ethnicity differences in birth defects rates.

While changes in demographics have occurred in birth profiles from 1988 to 1994, based upon the limited data available, there do not appear to be unusual birth outcomes in the Lompoc area during this period, as evidenced by either common congenital anomalies or low birth weights.

HOSPITAL DISCHARGES

Methods

Data for the hospital discharge analysis were abstracted from a public access database of discharges from California acute-care hospitals maintained by the Office of Statewide Health Planning and Development (OSHPD) of the California Department of Health Services (DHS). Hospital discharges cover overnight, or 24-hour or longer, hospitalizations and do not cover emergency room or outpatient visits. California acute-care hospitals include general acute-care hospitals, acute psychiatric hospitals, chemical dependency recovery hospitals, psychiatric health facilities, and state-operated hospitals, but do not include federal facilities (OSHPD, 1993). Data (Tape B format) were available for hospital number, patient's age (in 14 age groups), race, sex, Zip Code of the patient's home address (5 digits), length of hospital stay, quarter admitted, year admitted, source of admission, type of admission, principal diagnosis, other diagnoses, principal procedure, other procedures, disposition of patient, expected principal source of payment, days from admission to each procedure, Diagnosis Related Group, Major Diagnostic Category, total charges, principal external cause of injury, other external causes of injury, and county of residence of the patient. For this analysis, Lompoc was defined as Zip Codes 93436 (street addresses) and 93438 (post office boxes). Residents of Vandenberg Air Force

Base (VAFB), defined as Zip Code 93437, were excluded from Lompoc because VAFB is on a plateau and physically separate from Lompoc proper. Residents of VAFB were, however, included with Santa Barbara County. California nonfederal hospital discharges for 1991 to 1994 were used in the analysis.

During this four-year period, there were 21,145 hospital discharges in Lompoc; 133,383 for Santa Barbara County exclusive of Lompoc; 90,697 for San Luis Obispo County; 291,790 for Ventura County; 41,180 for Mendocino County, and 69,095 for Humboldt and Del Norte counties combined. As mentioned above, hospital discharge data in the OSHPD database cover all nonfederal hospital discharges within California. Santa Barbara County includes Vandenberg Air Force Base, which has a small hospital facility. Hospital discharges from Vandenberg Air Force Base are not available and hence not included.

It should be noted that hospital discharge data are used only as a comparative index of health. They are not incidence data; i.e., they do not necessarily represent new cases of a disease within a defined population over a specific period of time. Furthermore, multiple admissions of an individual for a particular diagnosis cannot be distinguished in this discharge data set; this is another departure from the concept of incidence, which would be the preferred data for investigations of illness. Hospital discharges represent only a small fraction of all illnesses and, with the exception of normal births, can reasonably be assumed to represent only serious illnesses. As such, they are intermediate between illness symptoms, for which treatment may or may not be sought, and the endpoint of mortality. Discharge data, therefore, generally underestimate the occurrence of illness within a community.

From a measurement perspective, hospital discharges have the advantage of being physician-diagnosed rather than self-reported, are coded by trained and certified personnel using the standardized ICD-9 coding structure (International Classification of Diseases, 9th Revision, of the World Health Organization), and are maintained as official records by the state.

The hospital discharge data were analyzed initially in terms of 18 hospital discharge categories, reported by Diagnosis-Related Group (DRGs) (Appendix C). The choice of these 18 discharge categories, covering acute and chronic illness, cancers, and birth outcome measures, represented professional judgments as to the major areas of concern expressed by the residents. A DRG is a classification of patients by diagnosis or surgical procedure (as well as other criteria, which may include age, the presence of complications, or other factors) into major diagnostic categories (each containing specific diseases, disorders, or procedures) for the purpose of determining reimbursement of hospitalization costs, based on the premise that treatment of similar medical diagnoses should generate similar costs (Hervis, 1993; OSHPD, 1993). Only discharge categories with a frequency count of greater than 20 discharges in Lompoc within the four-year period were analyzed to reduce small sample size variability.

By definition, DRGs do not constitute specific diagnoses of individual diseases. Because of this, additional comparisons were performed, as appropriate, based on grouped ICD-9 codes for the physician’s principal diagnosis. The principal diagnosis is defined as "the condition established, after study, to be chiefly responsible for occasioning the admission of the patient to the hospital for care" (OSHPD, 1993).

Statistical comparisons were made between Lompoc, the study site, and (1) Santa Barbara County exclusive of Lompoc (SB-Lom), (2) Ventura County (Ven), a coastal county adjacent to the southeast of Santa Barbara County, (3) San Luis Obispo County (SLO), a coastal county adjacent to the north of Santa Barbara County, (4) Mendocino County (Men), and (5) Humboldt and Del Norte (H+DN) counties combined. The three latter counties are located on the northernmost coast of California. The selection of comparison counties was based partly on the assumption that people compare themselves predominately to others in nearby or roughly similar areas, partly on staff judgments as to appropriate comparisons, and partly on suggestions from others outside of OEHHA. A profile of Lompoc and the comparison counties for both hospital discharge demographics and pesticide use is presented in Appendix D. This profile indicates that there is a wide range in demographic differences and in pesticide use among the compared areas. Since no single comparison county was likely to meet the statistical assumption of equivalence with Lompoc in all respects save the putative exposure, five comparison counties were used. In this way, the assumptions of demographic, occupational, pesticide use, and other differences could be explored.

The following statistical test assumptions were made in this analysis: that the comparison counties were roughly equivalent to Lompoc, except for the presumptive, but unknown, exposure variable(s) associated with Lompoc residence; that measurement biases that might be in the hospital discharge data (see below) were distributed similarly among areas of residence; and that there was no Lompoc-specific measurement bias. Additionally, it was assumed that every measurement was subject to some degree of measurement error and that these errors present challenges to interpretation but do not invalidate the data (Ames, 1996).

Analysis Methods

In the analysis protocol (PETS, 1997), rates were proposed as one of three methods of analysis. Rates of hospital discharge directly address the health concerns of the community, as they address the question of whether Lompoc residents were hospitalized more frequently on a per capita basis than the comparison populations. This method was not used, however, because census tract data were only available for 1990, and population estimates for 1991 to 1994 had to be extrapolated from the 1990 data. These estimates, provided by the California Department of Finance, were not considered to be reliable because they were based on criteria such as issuance of drivers licenses and automobile registrations, and it was not clear how the "city of Lompoc" was defined by the Department of Finance, such as with the use of census tracts, Zip Codes, or sections. The 1990 Census data were available for the "Lompoc Valley," whereas the Department of Finance data were identified only as "Lompoc." Also, there was almost a two-fold difference in the population estimates between these two sources.

The two other methods described in the protocol, proportional morbidity and morbidity odds ratios, were used in this analysis.

Proportional Morbidity

Proportional morbidity analysis was used to address the issue of whether certain illness categories were disproportionately greater in the mix of all hospital discharges. This method is similar to the method of proportionate mortality ratios (PMR) often employed in occupational epidemiology (Monson, 1980), except that age-adjustment, frequently employed in PMR studies, was infrequently used in our analysis. The proportion that a specific discharge category comprised of the total discharges for Lompoc was compared to the proportions in the five comparison counties. The ratios of the proportions are presented as odds ratios (OR), to provide an easy and verifiable method of calculation. An OR of 1.00 corresponds to the null hypothesis, i.e., that the proportion of diagnosis-specific discharges in Lompoc is not different from the proportions in the comparison areas. ORs greater than 1.00 reflect an elevated proportion for a specific discharge in Lompoc relative to the comparison county. Confidence intervals around the ratios of the proportions were calculated and are presented, along with precautionary notes, in the appendixes. Chi-square, a nonparametric test of association, was used to compute tests of significance for the hypotheses that hospital discharge proportions in Lompoc were not different from those in the comparison counties. The chi-square tests for the proportional method violate to some extent the assumption of independence since these proportions consist of disease-specific discharges and total discharges. The total, of course, includes the disease discharge(s) being tested. However, subtracting the disease-specific discharges from the total does not resolve the problem since it computes an incorrect odds ratio, changes the subject from a proportion to a ratio, and changes the hypothesis being tested to one comparing a disease to a non-disease. As noted subsequently in the section *Pattern Analysis*, the tests of significance generally are analyzed in terms of a pattern scale, but in some instances they are analyzed individually.

All odds ratios, chi-squares, and tests of statistical significance were computed using the microcomputer program, Epi-Info 6, version 6.02 (CDC, 1994). Total discharges were adjusted by subtracting births and deliveries, or other factors, as explained below. Subtracting births and deliveries removed a large number of discharges that were unrelated to any adverse medical condition and allowed for greater precision in estimates of the relative proportions. Also, some comparisons were based on subsets of discharges. For example, female-specific hospital discharges, such as female breast cancer, were compared to total female discharges, and similar comparisons were made for male-specific discharges. Abnormal birth outcomes and nontherapeutic abortions were compared to live births. Age and sex stratifications, and other similar cross-tabulations, were performed to assess the potential confounding effects of covariates, as appropriate. Age-adjustment, or control, was necessary because rates of many medical conditions are related to age. The potential effects of variables, such as smoking status, alcohol consumption, and other individual exposures, were not measured and hence could not be controlled in the analysis.

PROPORTIONAL MORBIDITY ANALYSIS

The analysis of ratios of proportions is used to measure excess risk of a disease, given exposure. In this analysis, residence in Lompoc is considered to be the exposure variable.

Example:

Assume:

Area	ICD-9(x)	Total Discharges
Lompoc	a	b
Comparison	c	d

For any specific ICD-9(x), the proportions (P) would be:

$$P_{Lompoc} = \text{ICD-9(x)}_{Lompoc}/\text{Total discharges}_{Lompoc} = a/b$$

$$P_{Comparison} = \text{ICD-9(x)}_{Comparison}/\text{Total discharges}_{Comparison} = c/d$$

$$\text{Ratio of proportions for ICD-9(x)} = P_{Lompoc}/P_{Comparison} = (a/b)\div(c/d)$$

$$\begin{aligned}\text{Ratio of proportions} &= (a/b)\div(c/d)\\ &= (a/b)\times(d/c)\\ &= ad/bc\end{aligned}$$

Morbidity Odds Ratios

Comparisons of hospital discharges also were made by calculating morbidity odds ratios (MOR). The analysis by MOR is a variant of the case-referent method, where cases of a specific disease are compared to subjects who have a disease thought not to be related to any presumptive exposures (Miettinen and Wang, 1981). Three reference series were used: (1) diseases and disorders of the circulatory system (DRGs 103-108, 110-145, 478-479); (2) diseases and disorders of the digestive system, excluding digestive cancer (DRGs 146-167, 170-171, 174-184, and 188-190); and (3) traumatic injury (ICD-9 codes E800-E999). Cases with a specific discharge category are compared against cases with a reference (control) discharge category, in contrast with proportional morbidity analysis, in which the proportion of cases with a specific discharge category are compared against all discharges. Since the MOR measurement does not represent a proportion, changes in the index for one discharge diagnosis do not necessarily affect the index for any other.

As with the proportional morbidity analysis, chi-square tests were used to compute tests of statistical significance, and confidence intervals were calculated around the odds ratios. In the morbidity odds ratio analyses, the disease and the reference category are independent; hence, the assumption of independence is not at issue. Confidence intervals and precautionary notes are presented in the appendixes. Again, we assumed that the comparison counties provided a relevant and meaningful basis for comparison.

MORBIDITY ODDS RATIO

The analyses by morbidity odds ratio is similar to case-referent analysis, where cases are examined relative to a presumptive exposure, and referents are cases of a disease thought to be independent of the given exposure.

Example:

MORBIDITY ODDS RATIO

Area	ICD-9(x)	Referent
Lompoc	a	b
Comparison	c	d

Morbidity odds ratio = ad/bc

Analysis of Potential Confounding Variables

Confounding is a "situation in which a measure of the effect of an exposure on risk is distorted because of an association of exposure [e.g., pesticide drift] with other factor(s) that influence the outcome [disease] under study" (Last, 1995). For example, in areas of high residential segregation, it may be virtually impossible to isolate the separate effects of race/ethnicity from the effects of residential location as these may combine the effects of a third variable, for example, some specific environmental exposure. If confounding exists, it can distort the estimates of the association between the exposure variable of interest and the disease under study. In this analysis, for potentially confounding factors to actually produce confounding, they would have to be related both to residence in Lompoc and to the health outcome measure(s). Chi-square analysis comparing Lompoc to the comparison counties was used to test seasonal variation, age, sex, and race/ethnicity variation as potential confounding effects. Confounding was also tested using discriminant function regression analysis.

The assessment of potential confounding was based upon two separate analyses. First, hospital discharges in Lompoc were compared to the five comparison counties in terms of each of the potentially confounding demographic factors: age, sex, race/ethnicity, births, admission quarter, and admission year (see Appendix J). By this procedure, one can determine, for example, if there is a greater proportion of females in Lompoc discharges, but one could not determine if females have a higher rate of hospital discharges because reliable data for the actual population at risk for the relevant years are not available. However, this initial tabulation is a first step in assessing potential confounding in this analysis because a factor has to be related to both the independent variable (Lompoc residence) and to the dependent variable (the category of hospital discharge) for actual confounding to occur.

The ICD-9-based disease-specific hospital discharges in Lompoc were then stratified by age, sex, and race/ethnicity to enable the disease-specific discharges in the same demographic category to be compared between Lompoc and the comparison counties.

This way, for example, if overall hospital discharges for one demographic factor or another were patterned differently in Lompoc compared to the comparison counties, then one could determine, through stratification, if a disease-specific discharge pattern was different in Lompoc relative to the comparison counties. If so, then the demographic factor and the discharge disease would likely be partially confounded.

One analysis of bronchitis and one analysis of asthma used age-adjustment based on a method by Boyle and Parkin (Jensen et al., 1991) employing the 14 age categories in the OSHPD data set. Confidence intervals around the OR at the 95% level were calculated as exp[ln OR ± 1.96 × s.e. ln OR], at the 99% level as exp[ln OR ± (2.58 × s.e. ln OR], and at the 99.9% level as exp[ln OR ± 3.30 × s.e. ln OR], where exp = exponent, ln = natural log, and s.e. = standard error. Boyle and Parkin suggest using the confidence interval around the OR as a means of avoiding problems associated with using chi-square with non-independent categories. This age-adjustment procedure provides a test of age-independence in the relationships being tested.

Discriminant Function Regression

In order to treat all measured potentially confounding variables together as predictors with the respiratory discharge categories of bronchitis and asthma, a discriminant function regression model was used (Morrison, 1967). This model addresses the question of whether or not classification as a Lompoc resident or as a control resident can be predicted by a model including asthma, bronchitis, age, sex, race/ethnicity, or admission quarter as independent variables. For this discriminant function analysis, the codes for the variables are listed below.

Codes for the Variables Considered in the Discriminant Function Regression Analysis

Lompoc residence (the dependent variable)	1 = Lompoc residence
	0 = Control county residence
Bronchitis (hypothesized predictor variable)	1 = Bronchitis (ICD-9-based)
	-1 = Not bronchitis
Asthma (hypothesized predictor variable)	1 = Asthma (ICD-9-based)
	-1 = Not asthma
Age (potential confounder)	1 = <5 years of age
	2 = 5-24 years of age
	3 = 25-59 years of age
	-1 = 60+ years of age
Sex (potential confounder)	1 = Males
	-1 = Females (non-males)
Race/ethnicity (potential confounder)	1 = Whites
	2 = Hispanics
	-1 = Other (blacks, Asians)
Admission quarter (potential confounder)	1 = January - March
	2 = April - June
	3 = July - September
	-1 = October - December

Pattern Analysis

In order to describe the pattern of discharge elevations, a six-point pattern analysis scale was developed (RG Ames) to measure consistency and strength of pattern when Lompoc was compared against the five comparison counties. The intent of this scale was to give primary emphasis to the number of statistically significant comparisons, and secondary emphasis to the strength of the relationships. The pattern analysis scale was as follows:

PATTERN ANALYSIS

SCALE	CRITERIA
5	5 statistically elevated county comparisons, all $p < 0.001$.
4	5 statistically elevated county comparisons, not all $p < 0.001$.
3	3 or 4 statistically elevated county comparisons, all $p < 0.001$.
2	3 or 4 statistically elevated county comparisons, not all $p < 0.001$.
1	1 or 2 statistically elevated county comparisons.
0	No statistically elevated county comparisons.

Aggregate Odds Ratios

In addition to the pattern scale, aggregate odds ratios were computed by adding data from all five comparison counties. The aggregate odds ratios were calculated to assess Lompoc compared against the five comparison counties added together in the proportional analysis and the five counties and three reference series added together in the morbidity odds ratio analysis. This procedure is similar to the concept of meta-analysis used to combine data from more than one study (Hennekens and Buring, 1987). Here, however, all the data were from the same overall analysis.

Results

Analysis Based on DRG Groupings

Proportional Morbidity

An initial analysis by DRG codes was conducted to identify the ICD-9-based discharge categories which would be used in the central analysis. This section is included in the report to document fully the sequence of analyses leading to the final results. Of the 18 Diagnosis Related Groups (DRGs) examined by the proportional morbidity method, five with a sample size of 20 or greater in Lompoc were elevated above a minimal suggestive pattern using the pattern scale (see Pattern Analysis 1, Panel 1, below). Two groups of discharge categories were consistently elevated when Lompoc was compared to the five comparison areas: stronger findings for a “respiratory” group and weaker findings for a “reproductive” group. For the respiratory group, the discharge category bronchitis and asthma showed the most consistently elevated relationship (score=5), followed by interstitial lung disease and otitis media and upper respiratory disease (URD) (both score=4). A lesser elevation was seen for reproductive discharges, consisting of abnormal birth outcomes (score=3), and female reproductive malignancy (score=2). Two DRG clusters had a score of 1 and are considered suggestive only: pleurisy and pneumonia, and female breast cancer. The aggregate odds ratios (Pattern Analysis 1, Panel 2) provide quantitative summary estimates of the elevation of respiratory discharges for bronchitis and asthma (OR=1.85), interstitial lung disease (OR=2.23), and otitis media and URD (OR=1.62), all significant at p<0.001. In addition, female reproductive malignancy (OR=1.49) is elevated at p<0.05. As a basis of comparison, an OR of 1.85, as in bronchitis and asthma above, indicates an 85% elevation in bronchitis and asthma discharges in Lompoc compared to the five comparison counties. The DRG category of abnormal birth outcomes, which was elevated in the pattern scale, was not significantly increased in the aggregate odds ratio analysis. This was true for pleurisy and pneumonia and female breast cancer, as well. Since the aggregate odds ratios are weighted averages, they are heavily influenced by Ventura County, which provides approximately half of the combined five county comparison discharges. Individual comparison county ORs are presented in Panel 2, as well. These individual county ORs show that for the four statistically significant aggregate OR discharge categories, the patterns of elevated Lompoc discharges were replicated to varying degrees in each county comparison.

Pattern Analysis 1. Lompoc vs. Comparison Counties by Diagnosis-Related Group Categories Using Proportional Morbidity: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
DRG Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Bronchitis and asthma	5	***	***	***	***	***
Interstitial lung disease	4	*	***	***	**	**
Otitis media & URD	4	***	***	*	***	***
Abnormal birth outcomes	3	***		***		***
Female repro malignancy	2		*	**	*	*
Pleurisy and pneumonia	1		**			
Female breast cancer	1					*

Panel 2. Odds ratios

	Aggregate	Lompoc vs:				
DRG Category	**OR**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Bronchitis and asthma (602)	1.85 ***	2.43	1.59	2.08	1.91	1.88
Interstitial lung disease (24)	2.23 ***	1.69	2.38	2.68	2.45	2.28
Otitis media & URD (61)	1.62 ***	1.61	1.59	1.42	2.01	1.95
Abnormal birth outcomes (1,077)	1.06, NS	1.72	0.89	1.16	0.86	1.32
Female repro malignancy (37)	1.49 *	1.25	1.55	1.65	1.51	1.60
Pleurisy and pneumonia (474)	1.05, NS	1.06	1.14	0.96	0.90	0.95
Female breast cancer (98)	1.08, NS	1.02	1.09	0.99	1.18	1.27

* = p<0.05; ** = p<0.01; *** = p<0.001; NS, not statistically significant.

Key: **DRG**, Diagnosis-related group; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **URD**, upper respiratory disease; **( )**, number of discharges for that category in Lompoc.

A summary of the odds ratios for the proportional morbidity DRG analysis is presented in Appendix E, and the complete statistical support for each proportional analysis test, including confidence intervals, tests of significance, and precautionary notes, is presented in Appendix F. The number of discharges for each discharge category in Lompoc is presented in Panel 2 of each pattern analysis, enclosed in parentheses, to provide the reader with an estimate of sub-sample sizes. Chi-square tests of statistical significance flagged with a precautionary note by the Epi-Info program, indicating expected values of less than five in the significance test computation, also are flagged with an "#" in the pattern analyses. Low predicted values in the tests of significance calculations mean that caution should be exercised in interpreting the odds ratios as well as the tests of significance. Only elevated relationships are identified by significance level in the pattern analyses, although complete data are presented in the appendixes.

Morbidity Odds Ratios

The results of the morbidity odds ratio analysis, repeating the preceding DRG proportional morbidity analysis, are shown in Pattern Analysis 2; statistical support is presented in Appendix G. The pattern interpretation employs the same 6-point pattern analysis scale, summarized over the five counties and over the three control series (circulatory and digestive diseases, and trauma) to yield a maximum score of 15.

The morbidity odds ratio method (Pattern Analysis 2, Panel 1) identified the same basic five patterns of elevation in Lompoc hospital discharges and in the same rank-order as the proportional morbidity analysis (Pattern Analysis 1), although the pattern scale scores were slightly different. For the respiratory disease discharges, the category of bronchitis and asthma was, again, the most consistently elevated DRG group (score=15), followed by interstitial lung disease and otitis media and URD, which were the next most elevated (score=12). Among the reproductive discharges, abnormal birth outcomes again had a higher pattern score than female reproductive malignancy (score=9 vs. score=5). The pattern analysis showed that kidney neoplasms were elevated in the morbidity odds ratio analysis, but not in the proportional morbidity analysis. In addition, two additional DRG categories were added to the suggestive pattern list showing statistically significant elevations using the MOR method: seizures and headaches, and respiratory malignancy; these were in addition to female breast cancer, which also was identified as suggestive of a pattern by the proportional analysis.

The aggregate odds ratios (Pattern Analysis 2, Panel 2) provide summary quantitative estimates and significance tests of the increases observed in the discharge categories identified above as the most highly patterned: bronchitis and asthma (OR=1.84), interstitial lung disease (OR=2.22), otitis media and upper respiratory disease (OR=1.62), and abnormal birth outcomes (OR=1.16), all significant at $p<0.001$.

The identification of elevated DRG discharges did not appear by visual inspection of the individual county-by-control series ORs to be significantly influenced by the selection of control series (circulatory and digestive diseases, or trauma). No formal statistical test was used to address this issue. In addition, both the proportional morbidity analysis method and the morbidity odds ratio method identified the same basic patterns, respiratory and reproductive, while the morbidity odds ratio pattern scale also identified one stronger discharge category and two additional weaker suggestive elevations; however, these additional discharge categories were not significantly elevated by the aggregate odds ratio method. Female reproductive malignancy, identified as significantly elevated in the proportional analysis, was not significant in the MOR analysis.

Pattern Analysis 2. Lompoc vs. Comparison Counties by Diagnosis-Related Group Categories Using Morbidity Odds Ratios: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
DRG Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Bronchitis and asthma vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
Interstitial lung disease vs:	**12**					
Circulatory	4	*	***	***	***	***
Digestive	4	*	***	***	**	***
Trauma	4	*	***	***	**	***
Otitis media & URD vs:	**12**					
Circulatory	4	**	**	**	***	***
Digestive	4	***	***	*	***	***
Trauma	4	**	**	*	**	***
Abnormal birth outcomes vs:	**9**					
Circulatory	3	***		***	***	***
Digestive	3	***		***	***	***
Trauma	3	***		***	***	***
Female repro. malignancy vs:	**5**					
Circulatory	2			**	*	*
Digestive	2		*	*		**
Trauma	1			*		**
Kidney neoplasm vs:	**3**					
Circulatory	1				*	*
Digestive	1					*
Trauma	1					*
Female breast cancer vs:	**3**					
Circulatory	1					*
Digestive	1					*
Trauma	1					**
Seizures and headaches vs:	**2**					
Circulatory	0					
Digestive	1					*
Trauma	1					**
Respiratory malignancy vs:	**1**					
Circulatory	0					
Digestive	0					
Trauma	1					*

(Continued)

Pattern Analysis 2 (cont.) Lompoc vs. Comparison Counties by Diagnosis-Related Group Categories Using Morbidity Odds Ratios: All Ages

Panel 2. Odds ratios

DRG Category	**Aggregate OR**	**Lompoc vs: SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Bronchitis and asthma (602) vs:	**1.84** ***					
Circulatory		2.37	1.50	2.25	2.06	2.00
Digestive		2.52	1.58	2.08	1.82	2.03
Trauma		2.29	1.54	2.04	1.66	2.17
Interstitial lung disease (24) vs:	**2.22** ***					
Circulatory		1.65	2.24	2.90	2.63	2.43
Digestive		1.76	2.37	2.68	2.33	2.45
Trauma		1.60	2.30	2.63	2.12	2.63
Otitis media & URD (61) vs:	**1.62** ***					
Circulatory		1.57	1.50	1.53	2.16	2.07
Digestive		1.68	1.58	1.41	1.91	2.10
Trauma		1.52	1.54	1.39	1.75	2.25
Abnrml birth outcome (1,077) vs:	**1.16** ***					
Circulatory		1.65	0.78	1.89	1.57	2.24
Digestive		1.76	0.82	1.74	1.38	2.27
Trauma		1.49	0.80	1.71	1.26	2.43
Female repro malignancy (37) vs:	**1.39**, **NS**					
Circulatory		1.13	1.35	1.70	1.51	1.64
Digestive		1.20	1.43	1.57	1.34	1.66
Trauma		1.09	1.39	1.54	1.22	1.78
Kidney neoplasm (34) vs:	**1.21**, **NS**					
Circulatory		0.99	1.20	1.20	1.61	1.52
Digestive		1.06	1.27	1.11	1.42	1.54
Trauma		0.96	1.23	1.09	1.30	1.65
Female breast cancer (98) vs:	**1.01**, **NS**					
Circulatory		0.92	0.95	1.02	1.18	1.30
Digestive		0.98	1.01	0.94	1.04	1.32
Trauma		0.89	0.98	0.92	0.95	1.41
Seizures and headaches (114) vs:	**0.87**, **NS**					
Circulatory		0.78	0.85	0.74	1.22	1.24
Digestive		0.83	0.90	0.68	1.08	1.25
Trauma		0.76	0.88	0.67	0.98	1.34
Respiratory malignancy (68) vs:	**0.99**, **NS**					
Circulatory		0.98	0.97	1.01	0.79	1.22
Digestive		1.04	1.03	0.93	0.70	1.23
Trauma		0.95	1.00	0.92	0.64	1.32

* = p<0.05; ** = p<0.01; *** = p<0.001; NS, not statistically significant.

Key: **DRG**, Diagnosis-related group; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men,** Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **URD**, upper respiratory disease; **abnrml**, abnormal; **repro**, reproductive; **( )**, number of discharges for that category in Lompoc.

Analysis Based on ICD-9 Codes

Respiratory Disease

All analyses subsequent to the initial runs using DRGs were based upon ICD-9 codes, thus allowing specific physician-diagnosed illnesses to be identified and analyzed. ICD-9 respiratory codes were drawn only from discharges grouped in the six respiratory DRG categories that were elevated in the initial analysis. As identified in Appendix C, these six groups are:

Group 1	Bronchitis and asthma,
Group 2	Interstitial lung disease,
Group 3	Otitis media and upper respiratory disease,
Group 7	Pleurisy and pneumonia,
Group 16	Chronic obstructive pulmonary disease (COPD), and
Group 17	Respiratory infection and inflammation.

In Pattern Analyses 3, 5, 6, and 7, which use ICD-9-based respiratory discharges for bronchitis and asthma, the sample was restricted to cases which were related to the six significant DRG groups identified above. Pattern Analyses 8 and 9, covering each of the four years, did not have this restriction placed upon the sample. There are approximately 300 additional discharges in Pattern Analyses 8 and 9 as a consequence of not restricting the sample. These 300 discharges represent those which had respiratory ICD-9 codes but were not grouped in the respiratory DRG categories listed above.

Only selected ICD-9 codes were analyzed based on decisions by the authors (see Appendix H). These selected ICD-9-based respiratory diseases were analyzed by the morbidity odds ratio method; a summary of the odds ratios is presented in Table 2. Pattern Analysis 3, for the ICD-9-based respiratory diseases using the morbidity odds ratio method, follows. The morbidity odds ratio pattern scale was scored first over each of the comparison counties by the 6-point pattern scale, and then summarized over the three MOR reference series, for a maximum score of 15. Statistical support for Pattern Analysis 3 is presented in Appendix H. Note that in Appendix H, various ICD-9 codes are grouped and subsequently re-grouped to facilitate analysis. ICD-9 codes that appear in a subsequent grouping are indicated by one or more “$” to indicate the number of previous inclusions.

The analysis of ICD-9-based respiratory diseases by the pattern scale using the morbidity odds ratio method with three reference disease series and five comparison counties showed trends consistent with the previous identification in the DRG-based analysis. Hospital discharges for bronchitis were highly elevated in Lompoc, as were discharges for asthma, both score 15 (Pattern Analysis 3, Panel 1). Discharges for chronic obstructive pulmonary disease (COPD), usually associated with cigarette smoking (Snider et al., 1994), were lower in Lompoc relative to the comparison counties, although the differences were not statistically significant (Table 2). Discharges for the category pneumonia and influenza were at comparable or lower levels than in other comparisons (Table 2). Discharges for interstitial lung disease, as reported by the ICD-9 codes, were not elevated in Lompoc, whereas when previously reported by the DRG codes, they were

Table 2. Morbidity Odds Ratios for Selected ICD-9-Based Respiratory Disease Categories Presented by Referent Series for Lompoc vs. Comparison Counties: All Ages

Panel 1. CIRCULATORY DISEASE

	Lompoc vs:				
Disease Category	**SB-L**	**SLO**	**Ven**	**Men**	**H+DN**
Bronchitis	1.72[3]	2.00[3]	1.43[3]	1.81[3]	1.81[3]
Sinusitis	2.93[2]	3.47[3]	2.24[2]	5.79[3]	3.38[2]
Pneumonia & influenza	0.85	1.02	1.00	0.87	0.91
COPD	0.64	0.88	0.86	0.73	0.61
Asthma	1.87[3]	2.10[3]	1.24[2]	1.76[3]	1.79[3]
Asthma & related diseases[4]	1.23[3]	1.53[3]	1.11	1.28[3]	1.19[2]
Interstitial lung disease	0.53	1.20	0.71	0.88	1.17
Other respiratory disease	1.37[1]	2.10[3]	1.53[2]	2.37[3]	1.69[3]
Respiratory insufficiency	2.09[1]	2.94[2]	2.54[2]	15.68[3]	2.56[2]

Panel 2. DIGESTIVE DISEASE

	Lompoc vs:				
Disease Category	**SB-L**	**SLO**	**Ven**	**Men**	**H+DN**
Bronchitis	1.85[3]	1.84[3]	0.86	1.60[3]	1.83[3]
Sinusitis	3.17[3]	3.20[2]	1.34	5.12[3]	3.41[3]
Pneumonia & influenza	0.93	0.94	0.60	0.77	0.92
COPD	0.61	0.81	0.52	0.65	0.62
Asthma	2.02[3]	1.94[3]	0.74	1.56[3]	1.80[3]
Asthma & related diseases[4]	1.33[3]	1.41[3]	0.66	1.13	1.20[2]
Interstitial lung disease	0.58	1.11	0.43	0.77	1.18
Other respiratory disease	1.48[2]	1.94[3]	0.92	2.10[3]	1.70[3]
Respiratory insufficiency	2.25[1]	2.71[2]	1.52	13.86[3]	2.59[2]

Panel 3. TRAUMA

	Lompoc vs:				
Disease Category	**SB-L**	**SLO**	**Ven**	**Men**	**H+DN**
Bronchitis	1.65[3]	1.81[3]	1.47[3]	1.46[3]	1.96[3]
Sinusitis	2.82[2]	3.14[2]	2.30[2]	4.67[2]	3.66[3]
Pneumonia & influenza	0.83	0.93	1.03	0.71	0.99
COPD	0.61	0.79	0.89	0.59	0.67
Asthma	1.80[3]	1.91[3]	1.27[3]	1.42[3]	1.93[3]
Asthma & related diseases[4]	1.19[2]	1.39[3]	1.14[1]	1.04	1.28[3]
Interstitial lung disease	0.51	1.09	0.73[1]	0.71	1.26
Other respiratory disease	1.32	1.91[3]	1.58[2]	1.91[3]	1.83[3]
Respiratory insufficiency	2.01[1]	2.67[2]	2.61[2]	12.65[3]	2.78[2]

[1] $p<0.05$
[2] $p<0.01$
[3] $p<0.001$
[4] Bronchitis, emphysema, and chronic airway obstruction.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **COPD**, chronic obstructive pulmonary disease.

significantly elevated. The difference between the two measures is the inclusion of ICD-9 code 135 (sarcoidosis) and ICD-9 code 518.3 (pulmonary eosinophilia) within the DRG category. The largest contributor to the category of interstitial lung disease in these data is “inhalation of food or vomitus” (ICD-9 code 507) and almost no cases are pneumoconioses or “dust diseases” (ICD-9 codes 500 through 505) (see Appendix H, Panel 1). When asthma was grouped with related respiratory diseases (bronchitis, emphysema, and chronic airway obstruction), the overall relationship was markedly reduced, from score 15 to score 6, indicating that asthma was predominantly responsible for the elevation in that grouping. The overall pattern in the morbidity odds ratio analysis indicated that respiratory disease in Lompoc was elevated relative to all comparison counties. Statistical significance of these patterns, and quantitative estimates of elevation, are presented in the aggregate odds ratios (Pattern Analysis 3, Panel 2). Bronchitis (OR=1.69) and asthma (OR=1.58) were both significant at $p<0.001$. The category “other respiratory diseases” (OR=1.35) was also elevated, but at $p<0.05$. Individual county-by-reference-comparison series showed that all significant aggregate ORs had the patterns of elevation essentially replicated in each individual OR.

Pattern Analysis 3. Lompoc vs. Comparison Counties for ICD-9-Based Respiratory Diseases Using Morbidity Odds Ratios: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Bronchitis vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
Asthma vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
Other respiratory diseases vs:	**12**					
Circulatory	4	**	**	***	***	***
Digestive	4	***	***	***	***	***
Trauma	4	**	**	***	***	***
Asthma & related resp. dis.† vs:	**6**					
Circulatory	2	***		***	***	**
Digestive	2	***	**	***		**
Trauma	2	***	*	***		***

(Continued)

Pattern Analysis 3. (cont.) Lompoc vs. Comparison Counties for ICD-9-Based Respiratory Diseases Using Morbidity Odds Ratios: All Ages

Panel 2. Odds ratios

ICD-9-Based Category	Aggregate OR	Lompoc vs: SB-L	Ven	SLO	Men	H+DN
Bronchitis (287) vs:	**1.69** ***					
Circulatory		2.04	1.43	2.00	1.81	1.81
Digestive		2.18	1.51	1.84	1.60	1.83
Trauma		1.98	1.47	1.81	1.46	1.96
Asthma (299) vs:	**1.58** ***					
Circulatory		2.22	1.23	2.08	1.75	1.77
Digestive		2.36	1.30	1.92	1.54	1.79
Trauma		2.15	1.26	1.89	1.41	1.91
Other resp. diseases (59) vs:	**1.35** *					
Circulatory		1.64	1.53	2.10	2.37	1.69
Digestive		1.75	1.62	1.94	2.10	1.70
Trauma		1.59	1.58	1.91	1.91	1.83
Asthma, rel. resp dis† (405) vs:	**0.99, NS**					
Circulatory		1.48	1.11	1.53	1.28	1.19
Digestive		1.57	1.17	1.41	1.13	1.20
Trauma		1.43	1.14	1.39	1.04	1.28

* = p<0.05; ** = p<0.01; *** = p<0.001; NS, not statistically significant.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **resp**, respiratory; **dis**, disease; **( )**, number of discharges for that category in Lompoc; **†,** includes bronchitis, emphysema, and chronic airway obstruction.

Reproductive Effects

Abnormal birth outcomes. Abnormal birth outcomes, when specified by ICD-9 diagnosis codes, showed a strong pattern for infant respiratory conditions (score=15) (see Pattern Analysis 4, Panel 1). Statistical support for Pattern Analysis 4 is presented in Appendix I. Low birth weight delivery showed a weaker pattern of elevation (score=6). In short, the DRG-based elevation in discharges for abnormal birth outcomes included a strong respiratory effect when specified by ICD-9 codes. A review of these respiratory discharges revealed that they were emergency and urgent care discharges of infants (defined as children under one year of age). The aggregate odds ratios confirmed the elevated relationships (Pattern Analysis 4, Panel 2). Discharges for respiratory disease (OR=2.58) were significant at p<0.001. The relationship for perinatal respiratory disease was reconfirmed when it was assessed against the number of births; this tabulation showed OR=2.38, p<0.001. Discharges for low birth weight also were elevated, but to a lesser degree (OR=1.64, p<0.05). The relationship for low birth weight failed to be reconfirmed as statistically significant when it was assessed against the number of births; this calculation showed OR=1.50 (NS, p=0.05). Individual ORs (Panel 2) showed elevated relationships in each county (except for low birth weight in comparison to San Luis Obispo County).

Pattern Analysis 4. Lompoc vs. Comparison Counties for ICD-9-Based Abnormal Birth Outcomes (Perinatal Respiratory Disease and Low Birth Weight) Using Morbidity Odds Ratios: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Perinatal resp. disease vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
Low birth weight vs:	**6**					
Circulatory	2	*	**		*	
Digestive	2	**	**		*	*
Trauma	2	*	**			*

Panel 2. Odds ratios

	Aggregate	Lompoc vs:				
ICD-9-Based Category	**ORs**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Perinatal resp. disease (74) vs:	**2.58** ***					
Circulatory		2.28	2.06	3.81	3.43	4.63
Digestive		2.43	2.17	3.51	3.03	4.68
Trauma		2.21	2.11	3.46	2.77	5.02
Low birth weight (21) vs:	**1.64** *					
Circulatory		1.87	1.82	1.11	2.03	1.66
Digestive		1.99	1.92	1.03	1.79	1.67
Trauma		1.81	1.87	1.01	1.63	1.79

* = p<0.05; ** = p<0.01; *** = p<0.001.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **resp**, respiratory; **( )**, number of discharges for that category in Lompoc.

Perinatal respiratory disease. The ICD-9-based category of respiratory discharges for infants, i.e., with abnormal birth outcome (DRG codes 385 through 390) and with perinatal respiratory disease (ICD-9 codes 768, 769, or 770; see Appendix I), was further analyzed by admission quarter to determine if the pattern for Lompoc differed from that of other comparison areas by season. No difference was seen between the quarterly pattern of infant respiratory discharges by admission quarter for Lompoc and those of the comparison counties (Table 3, Panel 1).

The perinatal respiratory disease categories used in this analysis, ICD-9 codes 768, 769, and 770, correspond to intrauterine hypoxia and birth asphyxia, respiratory distress syndrome, and a variety of other respiratory conditions of the fetus and newborn, respectively. These diagnostic categories comprise a diverse set of conditions leading to insufficient oxygen delivery to the fetus, newborn, or both, with resultant respiratory distress. Included among the conditions predisposing to these problems are aspiration of meconium in the amniotic fluid, premature delivery (before the infant's lungs have matured), congenital pneumonia acquired prenatally, pulmonary hemorrhage, and other disorders.

Table 3. Infant Perinatal Respiratory Discharges Among Discharges Identified as "Abnormal Birth Outcomes" by the Diagnosis-Related Group Codes by Admission Quarter

Panel 1. Respiratory discharges (DRGs 385-390 with ICD-9 codes 768, 769, or 770)

Area	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc	21	17	18	19	75
Comparison areas[1]	232	203	231	207	873

Chi-square = 0.30, df = 3, p = 0.960367, NS

Panel 2. Births

Area	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc	824	827	886	824	3,361
Comparison areas[1]	22,670	23,363	24,118	23,136	93,287

Panel 3. Odds ratios (pseudo rate)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc vs. Comparison areas[1]	2.49 ***[2]	2.37 ***	2.12 **	2.58 ***	2.39 ***

[1]Comparison counties are: SB-Lompoc, Ventura, San Luis Obispo, Mendocino, Humboldt, and Del Norte
[2]Formula: (21/824) ÷ (232/22670) = 2.49, and similarly, for each quarter.
* = p<0.05; ** = p<0.01; *** = p<0.001; NS = Not statistically significant

A pseudo-rate was calculated by comparing infant respiratory discharges by admission quarter to total live births in that quarter (Table 3, Panel 3; Appendix I, Panel 1). This measure is not a true rate since the population at risk of infant respiratory discharges includes all infants less than a year old, while these calculations assume a population at risk consisting only of live births during any given 3-month interval. In other words, the denominators for these rates include only about one-quarter of the children who are theoretically at risk for such respiratory discharges. On the other hand, most of the conditions encompassed by the relevant ICD-9 codes are likely to affect very young infants, so these pseudo-rates may represent reasonable approximations of the true rates. Moreover, this measure does provide a consistent and comparable index of the populations at risk. The pattern of births does not vary by admission quarter between Lompoc and the comparison counties (Appendix J, Panel 31). By this pseudo-rate calculation, which is computed using odds ratios, Lompoc infants consistently had a two-fold or greater risk of ICD-9-based respiratory discharges in each quarter compared with infants from the comparison counties (Table 3, Panel 3). The average risk over the four quarters was indexed by an Odds Ratio of 2.39 (Table 3, Panel 3; Appendix I, Panel 4).

Female reproductive malignancy. A breakdown of the DRG category of female reproductive malignancy (statistically significant in Pattern Analysis 1, Panel 2) by ICD-9 codes revealed no groupings of diagnoses with a sample size of 20 or greater in Lompoc; female reproductive malignancy thus was not analyzed further.

Potentially Confounding Effects

Without regard to the base population, overall hospital discharges for Lompoc differed from discharges in the comparison counties in terms of: (1) age, with statistically significantly more younger discharges in Lompoc, except compared to Ventura County (Appendix J, Panels 1-5); (2) sex, with fewer female discharges in Lompoc relative only to Santa Barbara County minus Lompoc and Ventura County (Appendix J, Panels 6 and 7); and, (3) race/ethnicity, with statistically significantly fewer Hispanics relative to Ventura County and to Santa Barbara County minus Lompoc, but greater numbers of Hispanics than San Luis Obispo, Mendocino, or Humboldt plus Del Norte counties (Appendix J, Panels 11-15). There was one discharge difference between Lompoc and Santa Barbara County minus Lompoc (Appendix J, Panel 16) relative to admission quarter (a measure of seasonal variation), with Lompoc having slightly greater first quarter admissions (other comparisons were not significant, Appendix J, Panels 17-20). There were no differences between Lompoc and comparison counties between births by sex (Appendix J, Panels 26-30). There were, however, statistically significant differences by admission year (Appendix J, Panels 21-25). These relationships are explored in greater detail by ICD-9-based discharge categories, below.

Age

When the ICD-9-based respiratory disease discharges were stratified by age, and looking at the dichotomization of the under 25-year versus the 25-year and older age categories, there were proportionally more discharges for bronchitis, pneumonia and influenza in Lompoc at under 25 years of age (Table 4, Panels 1 and 2), but proportionally fewer discharges for asthma (while the overall relationship was significant at $p<0.05$, the actual differences were small; Panel 3).

When analyzed by the proportional morbidity method, the strongest pattern scale relationship was for discharges of both bronchitis and asthma in the 60 year and older group, with a score=5 for both asthma and bronchitis (Pattern Analysis 5, Panel 1). Statistical support for Pattern Analysis 5 is presented in Appendix K. The only other strong patterns were for bronchitis at ages under 5, and asthma in the 25-59 year age group (both score=4). For the rest of the age categories, the patterns of elevated respiratory disease were only suggestive, absent, or likely to be unreliable due to small sample size. The aggregate odds ratio analysis confirmed the pattern scale findings (Pattern Analysis 5, Panel 2). Asthma was elevated in the 25-59 year age group (OR=1.55) and in the 60 and over age group (OR=1.97), both at $p<0.001$. Bronchitis was elevated in the <5 age group (OR=1.48), and in the 60 year and over age group (OR=1.56), both at $p<0.001$. Individual county ORs were elevated in each county when the aggregate ORs were statistically significant (Pattern Analysis 5, Panel 2).

Table 4. Selected ICD-9-Based Respiratory Disease Discharges by Age

Panel 1. Bronchitis

AREA	<5 yrs	5-24 yrs	25-59 yrs	60+ yrs	Total
Lompoc	38.0%	2.4%	10.5%	49.1%	100.0%
n	109	7	30	141	287
Comparison counties[1]	26.8%	1.5%	14.6%	57.3%	100.0%
n	1,374	78	754	2,965	5,171

Chi-square=20.98, df=3, p<0.001

Panel 2. Pneumonia and influenza

AREA	< 5 yrs	5-24 yrs	25-59 yrs	60+ yrs	Total
Lompoc	26.4%	7.7%	18.8%	47.1%	100.0%
n	138	40	98	246	522
Comparison counties[1]	15.2%	4.9%	16.4%	63.5%	100.0%
n	2,444	878	2,636	10,221	16,089

Chi-square=59.7, df=3, p<0.001

Panel 3. Asthma

AREA	< 5 yrs	5-24 yrs	25-59 yrs	60+ yrs	Total
Lompoc	25.4%	15.7%	31.8%	27.1%	100.0%
n	76	47	95	81	299
Comparison counties[1]	21.7%	23.7%	31.2%	23.4%	100.0%
n	1,247	1,363	1,792	1,348	5,750

Chi-square=11.2, df=3, p<0.05

n = number of discharges
[1]Comparison counties are: SB-Lompoc, Ventura, San Luis Obispo, Mendocino, Humboldt, and Del Norte

The asthma and bronchitis relationships, recalculated using age-adjustment by 14 age categories, are presented in italics in Pattern Analysis 5, Panel 2. These age-adjusted odds ratios show that overall relationships are reduced somewhat when age is taken into account, but that the relationships are not explained by age. The supporting calculations are presented in Appendix K, Panel 14.

Considering all three discharge categories for persons under 5 years of age, bronchitis, pneumonia and influenza, and asthma, each was disproportionately higher in Lompoc compared to the aggregate of the comparison counties.

Pattern Analysis 5. Lompoc vs. Comparison Counties for ICD-9-Based Respiratory Diseases Using Proportional Morbidity: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total	**5**	***	***	***	***	***
Asthma, <5 years	**1**	***				
Asthma, 5-24 years	**1**	**			*	
Asthma, 25-59 years	**4**	***	**	***	**	**
Asthma, 60+ years	**5**	***	***	***	***	***
Bronchitis, total	**5**	***	***	***	***	***
Bronchitis, <5 years	**4**	***	*	***	**	**
Bronchitis, 5-24 years	**2**	**	**	*		**
Bronchitis, 25-59 years	**0**					
Bronchitis, 60+ years	**5**	***	***	***	***	***

Panel 2. Odds ratios

	Aggregate	Lompoc vs:				
ICD-9-Based Category	**OR**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total (299)	**1.59** ***	2.27	1.30	1.92	1.62	1.66
Asthma, age-adjusted	***1.38*** ***†	*1.86*	*1.19*	*1.60*	*1.33*	*1.41*
Asthma, <5 years (76)	**1.14, NS**	1.78	1.01	1.21	0.95	1.13
Asthma, 5-24 years (47)	**1.20, NS**	1.59	1.04	1.32	1.52	1.22
Asthma, 25-59 years (95)	**1.55** ***	1.98	1.41	1.93	1.41	1.39
Asthma, 60+ years (81)	**1.97** ***	2.70	1.50	2.73	1.79	2.51
Bronchitis, total (287)	**1.69*****	2.09	1.51	1.84	1.68	1.70
Bronchitis, age-adjusted	***1.48*** ***†	*1.94*	*1.30*	*1.70*	*1.46*	*1.37*
Bronchitis, <5 years (109)	**1.48** ***	1.93	1.26	1.95	1.54	1.47
Bronchitis, 5-24 years (7)	**3.11** **#	3.35#	3.21#	2.78#	2.26#	3.55#
Bronchitis, 25-59 years (30)	**1.16, NS**	1.29	1.16	1.20	1.23	0.98
Bronchitis, 60+ years (141)	**1.56** ***	2.06	1.37	1.66	1.45	1.49

* = p<0.05; ** = p<0.01; *** = p<0.001; NS, not statistically significant.
Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **( )**, number of discharges for that category in Lompoc; **#,** indicates the corresponding chi-square test of significance calculation was flagged as having an expected value under 5; **†**, significance tests for the age-adjusted ratios are based on the 95%, 99%, and 99.9% confidence intervals (rather than chi-square tests).

Sex

When the ICD-9-based respiratory disease discharges were stratified by sex, the elevated relationship held up for both asthma and bronchitis discharges for both males and females; three of the four categories scored 5, and one scored 3 (Pattern Analysis 6, Panel 1). Statistical support for Pattern Analysis 6 is presented in Appendix L. The aggregate odds ratio analysis (Panel 2) showed all four elevations to be statistically significant at p<0.001. Individual county ORs (Panel 2) were statistically significantly elevated for each county comparison, except for asthma in males compared to Ventura County.

Pattern Analysis 6. Lompoc vs. Comparison Counties for ICD-9-Based Respiratory Diseases Using Proportional Morbidity: Both Sexes

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total	**5**	***	***	***	***	***
Bronchitis, total	**5**	***	***	***	***	***
Asthma, males	**3**	***		***	***	***
Bronchitis, males	**5**	***	***	***	***	***
Asthma, females	**5**	***	***	***	***	***
Bronchitis, females	**5**	***	***	***	***	***

Panel 2. Odds ratios

	Aggregate	Lompoc vs:				
ICD-9-Based Category	**OR**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total (299)	**1.59** ***	2.27	1.30	1.92	1.62	1.66
Bronchitis, total (287)	**1.69*****	2.09	1.51	1.84	1.68	1.70
Asthma, males (126)	**1.43** ***	1.93	1.17	1.67	1.70	1.57
Bronchitis, males (141)	**1.70** ***	2.11	1.54	1.89	1.70	1.58
Asthma, females (173)	**1.73** ***	2.60	1.43	2.16	1.61	1.75
Bronchitis, females (146)	**1.69** ***	2.08	1.49	1.81	1.67	1.82

* = p<0.05; ** = p<0.01; *** = p<0.001.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **( )**, number of discharges for that category in Lompoc.

Race/Ethnicity

When the ICD-9-based respiratory discharges were stratified by race/ethnicity, the patterns of elevation in Lompoc by the pattern scale were strongest for whites for both asthma and bronchitis, score 5, and weaker for Hispanics, score 4 for asthma and score 2 for bronchitis, (Pattern Analysis 7, Panel 1). Statistical support for Pattern Analysis 7 is presented in Appendix M. This pattern analysis was confirmed for three of four comparisons at p<0.001 (ORs 1.57, 1.66, and 1.61) using the aggregate odds ratios (Panel 2), and for bronchitis in Hispanics (OR=1.58, p<0.01). Individual county ORs (Panel 2) were significantly elevated for each comparison, except for bronchitis in Hispanics compared to Humboldt and Del Norte Counties.

Pattern Analysis 7. Lompoc vs. Comparison Counties for ICD-9-Based Respiratory Diseases Using Proportional Morbidity: All Races/Ethnic Groups

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total	**5**	***	***	***	***	***
Bronchitis, total	**5**	***	***	***	***	***
Asthma, whites	**5**	***	***	***	***	***
Bronchitis, whites	**5**	***	***	***	***	***
Asthma, Hispanics	**4**	***	**	**	*	*
Bronchitis, Hispanics	**2**	***	*	**	*	

Panel 2. Odds ratios

	Aggregate	Lompoc vs:				
ICD-9-Based Category	**OR**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
Asthma, total (299)	**1.59** ***	2.27	1.30	1.92	1.62	1.66
Bronchitis, total (287)	**1.69** ***	2.09	1.51	1.84	1.68	1.70
Asthma, whites (198)	**1.57** ***	2.37	1.32	1.78	1.47	1.54
Bronchitis, whites (206)	**1.66** ***	1.97	1.55	1.75	1.57	1.60
Asthma, Hispanics (55)	**1.61** ***	2.09	1.46	1.67	1.69	1.90
Bronchitis, Hispanics (45)	**1.58** **	2.38	1.36	1.71	1.73	1.55

* = p<0.05; ** = p<0.01; *** = p<0.001.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **( )**, number of discharges for that category in Lompoc.

Births

Roughly 16% of the total hospital discharges in Lompoc consisted of discharges identified as births. This was comparable to Santa Barbara County minus Lompoc, and Ventura County, both within a range of approximately 16%, but was higher than San Luis Obispo, Mendocino, or Humboldt and Del Norte counties, which were in the 10% to 12% range. The percent abnormal birth outcomes as defined by DRGs for Lompoc (roughly 32%) was within the range of the other counties which varied from 18% for the remainder of Santa Barbara County to a high of 37% for Mendocino County. (These data are not shown directly, but may be derived from Appendix F, Panel 2b). It should be noted that these data are for DRG-defined abnormal birth outcomes, and that DRGs were designed for hospital reimbursement purposes, not medical diagnosis. Even the births of twins is considered an abnormal outcome for medical reimbursement, since greater billing charges are associated with multiple births. Hence these data are not equivalent to the birth defects data previously presented.

Admission Quarter (Seasonal Variation)

Seasonal variations in discharges for bronchitis, asthma, and pneumonia and influenza were not significantly different in Lompoc versus the control counties (Table 5).

Table 5. Selected ICD-9-Based Respiratory Disease Discharges by Admission Quarter

Panel 1. **Bronchitis** (in percentages)

AREA	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc	42.2%	19.5%	15.4%	22.9%	100.0%
n	124	57	45	67	293
Comparison counties[1]	37.7%	20.4%	14.2%	27.7%	110.0%
n	2,108	1,141	794	1,549	5,592

Chi-square=4.31, df=3, p=0.230023, NS

Panel 2. Pneumonia and influenza (in percentages)

AREA	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc	34.1%	23.8%	16.6%	25.5%	100.0%
n	189	132	92	141	554
Comparison counties[1]	34.0%	21.5%	16.1%	28.4%	100.0%
n	5,644	3,569	2,673	4,714	16,600

Chi-square=3.03, df=3, p=0.387692, NS

Panel 3. Asthma (in percentages)

AREA	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Lompoc	28.0%	24.4%	21.5%	26.1%	100.0%
n	86	75	66	80	307
Comparison counties[1]	27.5%	21.7%	21.3%	29.5%	100.0%
n	1,597	1,260	1,237	1,713	5,808

Chi-square=2.28, df=3, p=0.516319, NS

[1]Comparison counties are: Santa Barbara County-Lompoc, Ventura, San Luis Obispo, Mendocino, Humboldt, and Del Norte counties.

Key: **n**, number of discharges; **NS**, not statistically significant.

Admission Year

Evaluation of whether the patterns of elevated hospital discharges were repeated each year rather than being the artifact of a once-only pattern was performed by calculating the ICD-9-based discharge patterns separately for bronchitis and asthma by year. In this analysis, the sample was not restricted to cases from the six significant respiratory DRG groups, but included approximately 300 cases with ICD-9-based asthma and bronchitis codes that were not grouped within one of the six elevated respiratory DRG groups.

Bronchitis discharges were elevated in Lompoc in each individual year, as shown in Pattern Analysis 8. In some years the elevation was stronger than in other years; for bronchitis, the pattern scale score ranged from 6 to 15 (Pattern Analysis 8, Panel 1).

Statistical support is presented in Appendix N. This pattern was confirmed by the aggregate odds ratio analysis (Panel 2). The bronchitis discharge elevation was strongest in 1992 and 1994 (ORs 2.06 and 1.64, respectively, both $p<0.001$), and weaker, but statistically significantly elevated in 1991 (OR=1.50, $p<0.01$) and 1993 (OR=1.39, $p<0.01$). Individual year-by-county-by-reference series ORs, (Panel 2) showed elevations in each comparison; however, not all were statistically significant.

The pattern for elevated asthma discharges was strongest in 1991 and 1992, and less so in 1993 and 1994, but was very similar in each of the 4 years; the pattern score ranged from 3 to 15 (Pattern Analysis 9, Panel 1). Statistical support is presented in Appendix N. The weakest elevation for both bronchitis and asthma occurred in 1993 (Pattern Analyses 8 and 9). The aggregate odds ratios (Pattern Analysis 9, Panel 2) identified the asthma discharges to be elevated in 1991 and 1992 (OR=2.03 and 1.73, respectively, $p<0.001$). The relationship was not significant in 1993 (OR=1.14, not significant) and was weak in 1994 (OR=1.34, $p<0.05$). Individual ORs (Panel 2), were elevated in the years where the aggregate OR was statistically significant, except in relation to Ventura County in 1994.

Pattern Analysis 8. Lompoc vs. Comparison Counties for ICD-9-Based Bronchitis Discharges by Admission Year Using Morbidity Odds Ratios: All Ages

Panel 1. Pattern scale

		Lompoc vs:				
ICD-9-Based Category	**Score**	**SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
1991 - Bronchitis vs:	**6**					
Circulatory	2	***	*	***	**	
Digestive	2	***	**	***	*	
Trauma	2	***	*	***		*
1992 - Bronchitis vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
1993 - Bronchitis vs:	**7**					
Circulatory	3	***		***		***
Digestive	2	***		**		***
Trauma	2	***		**		***
1994 - Bronchitis vs:	**12**					
Circulatory	4	***	*	***	***	***
Digestive	4	***	**	***	***	***
Trauma	4	***	*	***	***	***

(Continued)

Pattern Analysis 8 (cont.) Lompoc vs. Comparison Counties for ICD-9-Based Bronchitis Discharges by Admission Year Using Morbidity Odds Ratios: All Ages

Panel 2. Odds ratios

ICD-9-Based Category	Aggregate OR	Lompoc vs: SB-L	Ven	SLO	Men	H+DN
1991 - Bronchitis (67) vs:	**1.50** **					
Circulatory		1.89	1.33	1.81	1.58	1.28
Digestive		2.02	1.41	1.66	1.40	1.29
Trauma		1.83	1.37	1.64	1.28	1.38
1992 - Bronchitis (90) vs:	**2.06** ***					
Circulatory		2.22	1.80	2.50	2.13	2.34
Digestive		2.36	1.90	2.31	1.88	2.36
Trauma		2.15	1.85	2.27	1.72	2.53
1993 - Bronchitis (66) vs:	**1.39** **					
Circulatory		1.69	1.13	1.72	1.34	1.81
Digestive		1.80	1.19	1.58	1.18	1.83
Trauma		1.63	1.16	1.56	1.08	1.96
1994 - Bronchitis (70) vs:	**1.64** ***					
Circulatory		2.17	1.34	1.81	2.35	1.70
Digestive		2.31	1.41	1.67	2.07	1.72
Trauma		2.10	1.37	1.64	1.89	1.85

* = p<0.05; ** = p<0.01; *** = p<0.001.

Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **( )**, number of discharges for that category in Lompoc.

Pattern Analysis 9. Lompoc vs. Comparison Counties for ICD-9-Based Asthma Discharges by Admission Year Using Morbidity Odds Ratios: All Ages

Panel 1. Pattern scale

ICD-9-Based Category	Score	Lompoc vs: SB-L	Ven	SLO	Men	H+DN
1991 - Asthma vs:	**15**					
Circulatory	5	***	***	***	***	***
Digestive	5	***	***	***	***	***
Trauma	5	***	***	***	***	***
1992 - Asthma vs:	**12**					
Circulatory	4	***	*	***	***	***
Digestive	4	***	**	***	***	***
Trauma	4	***	*	***	**	***
1993 - Asthma vs:	**3**					
Circulatory	1	*		**		
Digestive	1	**		*		
Trauma	1	*		*		
1994 - Asthma vs:	**6**					
Circulatory	2	***		**	**	***
Digestive	2	***		**	*	***
Trauma	2	***		**		***

(Continued)

Pattern Analysis 9 (cont.) Lompoc vs. Comparison Counties for ICD-9-Based Asthma Discharges by Admission Year Using Morbidity Odds Ratios: All Ages

Panel 2. Odds ratios

ICD-9-Based Category	**Aggregate OR**	**Lompoc vs: SB-L**	**Ven**	**SLO**	**Men**	**H+DN**
1991 - Asthma(114) vs:	**2.03** ***					
Circulatory		2.75	1.62	2.70	2.20	2.16
Digestive		2.94	1.71	2.48	1.94	2.18
Trauma		2.67	1.66	2.44	1.77	2.34
1992 - Asthma (81) vs:	**1.73** ***					
Circulatory		2.54	1.31	2.33	1.95	2.00
Digestive		2.70	1.38	2.14	1.73	2.02
Trauma		2.46	1.34	2.11	1.58	2.16
1993 - Asthma (54) vs:	**1.14, NS**					
Circulatory		1.48	0.92	1.56	1.13	1.20
Digestive		1.58	0.97	1.44	1.00	1.22
Trauma		1.43	0.95	1.41	0.91	1.30
1994 - Asthma (58) vs:	**1.34** *					
Circulatory		2.08	1.00	1.63	1.73	1.69
Digestive		2.22	1.05	1.50	1.53	1.71
Trauma		2.02	1.02	1.48	1.39	1.84

* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$; NS, not statistically significant.
Key: **ICD-9,** International Classification of Diseases, 9th revision; **OR**, Odds ratio; **SB-L**, Santa Barbara County minus Lompoc; **Ven,** Ventura County; **SLO**, San Luis Obispo County; **Men**, Mendocino County; **H+DN**, Humboldt plus Del Norte counties; **( )**, number of discharges for that category in Lompoc.

Discriminant Function Analysis

Based upon the results of the discriminant function regression model, Lompoc versus comparison county classification is significantly related to the regression model composed of illness discharge categories and potentially confounding effects. Stated another way, the factors such as asthma and bronchitis discharge, age, sex and race/ethnicity predict area of residence. The Analysis of Variance (ANOVA) table follows:

Analysis of Variance

	Degrees of Freedom	Sum of Squares	Mean Square
Regression	6	19.7887	3.29814
Residual	647,283	20,434.46815	0.03157

$F = 104.47215$ Significance of F $p < 0.001$

In a regression model, the effects of each predictor are adjusted to take into account the explanation of the other predictor variables in the system. The weights in the column labeled "ß" (beta) in the following regression model are adjusted and normalized slopes; that is, they can be interpreted and compared to one another.

Regression Model

Variable	b	SE(b)	ß	T	Sig T
Bronchitis	0.009793	0.001182	0.010314	8.285	p<0.001
Asthma	0.008319	0.001135	0.009107	7.329	p<0.001
Age	0.000813	0.000130	0.007854	6.256	p<0.001
Sex	0.001340	0.000227	0.007387	5.896	p<0.001
Race/ethnicity	-0.006820	0.000324	-0.026145	-21.03	p<0.001
Adm. Quarter	0.000078	0.000149	0.000648	0.522	NS
(Constant)	0.056907	0.001669		34.10	p<0.001

Key: **b**, regression coefficient; **SE(b)**, standard error of b; **ß**, standardized regression coefficient; **T**, t-test value; **sig T**, probability that H_o is false; **NS**, not statistically significant

Based upon the discriminant function regression model, all predictors, except admission quarter, are significantly related to categorization of the hospital discharges as coming from Lompoc or from the control counties. According to the ß weights, bronchitis is a modestly stronger predictor of residence than asthma (ß=0.01 vs. ß=0.009, respectively). Among the potentially confounding factors, age is slightly more important than sex in distinguishing residence (ß=0.007854 vs. ß=0.007387, respectively). Race/ethnicity shows up as a statistically significant predictor of residence location in this model, but this is due to the inclusion of the category "other races" (predominantly Blacks and Asians). Since the "other races" category was not examined in any of the preceding odds ratio analyses, and since "other races" totaled only 6.9% of all discharges, the analysis was re-run excluding discharges listed as "other races." When the "other races" were removed, race/ethnicity was not a predictor of residence (these data are not shown).

In summary, based upon a discriminant function analysis, bronchitis and asthma discharges, independent of the measured potentially confounding factors, distinguish between Lompoc residence and residence in the control counties. The discriminant function analysis is consistent with, and confirms, the analyses based upon odds ratios. The potentially confounding factors, either by themselves or taken together, do not explain the unique relationship between elevated respiratory discharges and Lompoc residence.

Area Specificity

To address the issue of whether or not other areas nearby Lompoc were experiencing health problems similar to Lompoc residents' complaints, such as respiratory disease, but were not expressing concerns in the form of community action or formal complaint, data from the towns surrounding Lompoc on the north and south were analyzed with respect to

ICD-9-based bronchitis, asthma, and perinatal hospital discharges. These towns included Santa Maria and Guadalupe to the north, which were combined due to size, and Buellton, Solvang, and Santa Ynez, to the south. Of these towns, Santa Maria is most like Lompoc in terms of size and proximity to agriculture. However, Santa Maria lacks the topography characterizing Lompoc, including hills that channel and stall the air over the town. In addition, data were analyzed from Salinas, 200 miles to the north, which was selected because it is surrounded by agriculture with extensive use of pesticides. Asthma, bronchitis, and perinatal respiratory discharges in these towns were compared to discharges in the aggregate 5-county comparison area using age-adjusted proportional morbidity analysis.

None of these towns showed significantly different respiratory discharges proportionally for bronchitis, asthma, and perinatal hospital discharges compared to the five-county comparison area. The significance level was tested using the 95%, 99%, and 99.9% confidence intervals. The calculated ORs for these comparisons are presented in Table 6, and the supporting data are presented in Appendix O.

Table 6. Age-Adjusted Odds Ratios for ICD-9-Based Respiratory Disease Discharges for Various California Towns vs. the Five-County Aggregate Comparison Area

	Odds Ratios		
Town	**Bronchitis**	**Asthma**	**Perinatal Respiratory Disease**
Santa Maria+Guadalupe	0.90, NS[1]	0.85, NS	1.02, NS
Buellton	0.45, NS	0.81, NS	--[2]
Solvang	0.58, NS	0.47, NS	--
Santa Ynez	0.87, NS	0.81, NS	--
Salinas	1.17, NS	0.92, NS	1.02, NS

[1]Statistical significance based on confidence intervals. NS, not significant at the 95%, 99%, or 99.9% level.
[2]Frequency count <20 discharges; data not presented.

In summary, this area-specific analysis indicates that Lompoc itself, not the surrounding area, has elevated proportions of bronchitis, asthma, and perinatal respiratory discharges. Lompoc also appears to be different from another agricultural area with extensive pesticide use, Salinas, which did not have increased proportions of respiratory-related discharges.

Source of Payment

In response to reviewers' comments, source of hospital payments for Lompoc was analyzed. This analysis was conducted on the 1990 OSHPD data, not otherwise presented in this report.

Source of payment for Lompoc discharges was compared with source of payment for Santa Maria + Guadalupe, nearby towns also surrounded by agricultural operations, but not exhibiting the elevated respiratory discharges that characterize Lompoc. These 1990 data show Lompoc to have a lower proportion of hospitalizations covered by Medicare and MediCal, and a slightly lower proportion covered by Workers Compensation. Lompoc has a higher rate of hospitalizations paid for by other government coverage. Lompoc also had a higher proportion of hospitalizations with some type of medical coverage than Santa Maria + Guadalupe (see below).

Source of Payment	Lompoc	Santa Maria + Guadalupe
Medicare/MediCal	45.4%	60.7%
Workers' Compensation	2.0%	2.5%
Other Government	3.9%	1.1%
Self-pay	6.8%	14.1%

Discussion

The hospital discharge analysis covering the years 1991 through 1994 shows elevated hospital discharges for bronchitis, asthma, and perinatal respiratory disease in Lompoc relative to the comparison counties. Bronchitis and asthma discharges were elevated approximately equally when the two discharge categories were analyzed separately by ICD-9 codes (bronchitis increased 69% and asthma increased 58%). Bronchitis discharges were significantly elevated in the youngest and oldest age groups (<5 and ≥60 years old) while asthma discharges were significantly elevated only among adults older than 25 years. There was no difference between the seasonal variation in Lompoc and the seasonal variation in the comparison counties when bronchitis or asthma discharges were compared by admission quarter.

Asthma is a chronic respiratory condition characterized by intermittent episodes of reversible bronchoconstriction that can be provoked by a variety of stimuli, including respiratory infections, exposure to allergens and air pollutants, pharmacological spasmogens, cold air, and other agents. The fundamental pathology in asthma is chronic airway inflammation, which is associated with hyperresponsiveness, episodic airflow limitation and respiratory symptoms, including cough, wheeze, chest tightness, excess phlegm production, and difficulty breathing. Hyperresponsiveness refers to an enhanced tendency of the airways to constrict in response to a variety of nonspecific stimuli, including respiratory irritants. Numerous reports demonstrate marked increases in asthma prevalence, morbidity, and mortality in the U.S. and other countries beginning in the late 1970s (CDC, 1992; 1995). While some fraction of the increase is probably attributable to changes in coding and in physicians' diagnostic labeling of asthma versus other respiratory illnesses, these factors cannot explain the entire phenomenon (Gergen and Weiss, 1992). In the U.S., much of the increase has occurred among children and adolescents (Evans and Gergen, 1996). Asthma usually begins in early childhood, but can develop at any age. Some recognized risk factors for developing asthma include a family history of asthma or allergy, exposures of people with an allergic predisposition to inhalant allergens (such as dust mites or cat dander), repeated lower respiratory infections in early childhood, prenatal and early childhood exposure to second-hand smoke, and exposures to certain respiratory irritants, especially at work.

Acute bronchitis is usually caused by viral infection involving the large airways, though secondary infection with bacteria can occur, often concomitant with influenza infection. Bronchitis frequently occurs following an upper respiratory infection, and is characterized by cough (with or without expectoration of phlegm), hoarseness, substernal chest pain, and malaise. Fever may also occur. Most cases of bronchitis can be treated on an outpatient basis. However, in patients with pre-existing conditions (e.g., asthma, chronic obstructive lung disease, or immunosuppression), adequate treatment of bronchitis may require hospitalization. Symptomatic acute bronchitis can occur following exposure to irritant chemicals as well, most commonly in an occupational context.

An initial finding related to elevated abnormal birth outcomes (by DRGs) was found, upon specification by ICD-9 codes, to have a component of emergency and urgent care respiratory hospitalizations among infants, i.e., those aged 0 to 12 months. These infant respiratory hospitalizations were not explained by season of the year (ORs above 2.0 in each quarter).

Elevated respiratory discharges were not explained by the potentially confounding variables of season, age, sex, or race/ethnicity, although age was identified as a partially confounding factor. These results were corroborated in the discriminant function analysis, which indicated a relationship between Lompoc residence and asthma and bronchitis discharges independent of the influence of the postulated confounding variables. Overall, Lompoc respiratory discharges were elevated in relation to other adjacent or relatively distant counties, and hence whether the comparison counties were similar or dissimilar with respect to demographics, pesticide use, or other characteristics.

Although the results presented here cannot be explained by confounding by the variables used in the analysis, it is possible that systematic differences in individual exposures may have confounded the results. However, data on personal factors, such as alcohol and tobacco use, were not available, and therefore these variables could not be controlled for. Nevertheless, it is unlikely that exposures to cigarette smoke, which has been linked with exacerbations of asthma, could explain this difference, as the bulk of the published evidence links increased numbers of asthma episodes among asthmatic *children* exposed to tobacco smoke and not adults (OEHHA, 1997). Somewhat more indirect evidence was provided by lower than expected discharges in Lompoc for chronic obstructive pulmonary disease (COPD), suggesting a lower prevalence of smoking in adults.

Theoretically it is possible that these results might be due to a statistical artifact: when numerous comparisons are made in an analysis such as this, some statistically significant findings can emerge by chance alone (Namboodiri, et al., 1975). We tried to address this possibility through the use of multiple methods of analysis and reference groups, summarized in the pattern analyses. Since both the proportional morbidity and morbidity odds ratio methods of analysis identified the same basic discharge patterns, and since the pattern scales and aggregate odds ratios were used to summarize over the five counties and the three reference series, potential problems associated with false positives due to the large number of multiple statistical comparisons do not appear to be an important issue. The elevated respiratory hospital discharges were confirmed using multiple methods, multiple county comparisons, multiple reference series comparisons in the morbidity odds ratio analysis, and replication of bronchitis and asthma elevations in each of four separate years (the exception was asthma in 1993). In addition, the usual way to compensate for multiple comparisons is to designate *a priori* a more stringent test of statistical significance (i.e., with the level of significance set lower than 0.05). Here the elevations in discharges for asthma and bronchitis were consistently significant, with p-values <0.001, also suggesting that these findings were highly unlikely to be due to chance.

The elevation of hospital discharges for respiratory illness in Lompoc relative to comparison counties raises the question of whether or not incidence rates also were elevated for these discharge categories. However, it is possible that one or more biases, or systematic differences in hospitalization patterns between Lompoc and the comparison counties, may have influenced the results. For example, differences in admissions criteria applied by local physicians or by insurance carriers may explain some of the apparent elevations in respiratory admissions in Lompoc. Because Lompoc is a relatively small community, local diagnostic patterns and admissions preferences could have a significant impact on hospitalizations for bronchitis and asthma relative to the comparison communities. For example, some of the patients ≥60 years who had pre-existing chronic lung disease exacerbated by bronchitis may have received the latter diagnosis in Lompoc, while elsewhere their hospitalization might have been attributed to their underlying condition. This could result in spuriously higher numbers of discharges for bronchitis in Lompoc. Moreover, a few individuals with brittle, difficult-to-manage asthma, who require frequent hospital admissions to treat potentially life-threatening exacerbations, could disproportionately affect the Lompoc numerators in these analyses since the OSHPD database did not have available information to allow us to cull out multiple hospitalizations for an individual for the same illness(es). Furthermore, it is possible (but in our opinion unlikely due to their small numbers) that the systematic exclusion from this database of Lompoc residents whose medical needs are addressed at Vandenberg Air Force Base could have influenced these results.

If one assumes that there are real differences in hospital admission patterns for respiratory disease between Lompoc and the comparison areas, there are several possible hypotheses that could be investigated as possible explanations. First, the significant increases in adult asthma admissions is in contrast to recent hospitalization patterns in many other locations, which tend to be dominated by pediatric admissions (Evans and Gergen, 1996; Gergen and Weiss, 1992), suggesting that there may be one or more sources of occupational asthma in Lompoc. The lack of seasonal differences in admission patterns in Lompoc in relation to the comparison counties suggests that the influence of aeroallergens (e.g., pollens or molds) is not likely to be substantially different in the study and comparison areas, though the local topography may lead to a greater intensity of exposure to such allergens. As respiratory infections represent the most common cause of severe exacerbations of asthma (McFadden, 1991), it is possible that respiratory epidemics in a small community such as Lompoc may link admission patterns for asthma with those for bronchitis. Still, without additional data, these potential etiologic explanations must remain speculative.

Except for normal childbirth and cosmetic surgery, only serious illnesses require hospitalization. Most acute illnesses receive either no treatment, home treatment, or over-the-counter remedies, a visit to a clinic or doctor's office, or urgent/emergency care treatment, depending upon the severity of the symptoms, presence or absence of medical insurance coverage, the person's past experiences with similar symptoms, and his/her expectation that useful treatment will be obtained. Thus, hospitalization records are likely to represent only the "tip of the iceberg" of illnesses in a community.

This hospital discharge analysis, therefore, cannot fully address the Lompoc residents' concerns. As noted, hospital discharges capture only serious illness, not the range of possible illness severity. The residents' concerns included a variety of respiratory and other symptoms, as well as increased mortality. In addition to this and other limitations of the analysis described above, there are several other reasons to interpret these data with caution. The analysis was limited to the years 1991 through 1994 and did not address what preceded or followed this period. There is no perfect comparison area for Lompoc; for this reason five comparison counties were used. Ventura County, having almost as many discharges as the other comparison counties combined, heavily influenced the weighted average comparisons, i.e., the aggregate odds ratios. MediCal insurance coverage as a factor in hospitalization was not examined. Specific location of residence within Lompoc was not available. No exposure variables were measured; therefore, this analysis does not examine cause-and-effect relationships to explain any health outcomes. Finally, although hospital admission *rates* could provide additional insights about health and illness in the community, we did not conduct this analysis because the official population estimates for the Lompoc area we obtained were widely discrepant, diverging by almost two-fold.

In contrast to the concerns raised above, there are major strengths for the hospital discharge analysis. The analysis is based upon a large sample size (647,290 discharges), covers a four-year time period, uses five separate comparison counties, focuses the major part of the analysis upon physician diagnoses, and uses the hospital discharge database, which is maintained as an official record by the state of California, and as such, has been subject to extensive quality assurance.

RESPIRATORY DISEASES AND POTENTIAL EXPOSURES

The evaluation of available health data as indicators of illness revealed that hospital discharges for selected respiratory illnesses appear to be elevated in Lompoc relative to the comparison areas. The proportion of hospital discharges for asthma, bronchitis, and perinatal respiratory disease with respect to total hospital discharges was higher in Lompoc compared to Santa Barbara County minus Lompoc, and the other five comparison counties. This trend was not observed in nearby towns relative to the county comparison areas. Additionally, the incidence of lung and bronchus cancers was significantly elevated in Lompoc compared to regional rates. We did not look at cancer incidence in the other towns.

As mentioned previously, the purpose of this evaluation was to determine if any illnesses were elevated in Lompoc, and not to determine any cause of any illness elevations. Presently, there are limited environmental monitoring data available specific to Lompoc, such as ambient air concentrations of pesticides, allergens (pollens, molds, fungi), limited monitoring on air toxics and air pollutants, nor any information on tobacco use or occupational exposures. Therefore, we do not know if the nonmalignant respiratory diseases and the lung and bronchus cancers are linked by a common exposure.

Pesticide exposure has been a primary concern of some residents of Lompoc. With regard to the nonmalignant respiratory diseases, as well as the range of symptoms reported to us by some Lompoc residents, it is possible that acute or chronic exposure to pesticides could be a factor. For example, organophosphate pesticides can cause a wide range of symptoms, such as flulike symptoms and respiratory distress, consistent with the complaints received from some residents. Organophosphate toxicity typically is associated with acute, or short-term, exposure to larger amounts, such as during an accidental spill. Yet the concerns of the residents relate more to long-term exposure to low levels of pesticides. Unfortunately, there is an absence of data pertaining to chronic effects from low-level exposure to pesticides in humans, especially from mixtures of pesticides. Nevertheless, without exposure data, OEHHA cannot determine if there is a link between pesticide use near Lompoc and the apparent elevations in respiratory diseases.

A likely cause for the increased incidence of lung and bronchus cancers observed in Lompoc is tobacco use, which is responsible for about 87% of all lung cancers (ACS, 1997). Kidney cancer also is associated with smoking, and the incidence of kidney and renal pelvis cancers was elevated in Lompoc, but the increase was not statistically significant. Although an increased risk of lung cancer has been associated with agricultural occupations (Barthel, 1981; Blair et al., 1983), few studies have actually documented exposure to specific pesticides. Arsenic, a known human carcinogen (IRIS, 1995), is the only pesticide for which we could find positive evidence associating exposure with lung cancer (Maroni and Fait, 1993; Mabuchi et al., 1979). Nevertheless, arsenicals were not used in Lompoc during the years 1991 to 1995 (Johnson, 1997). We do not know to what extent arsenicals were used prior to 1991.

Occupational exposure to silica, specifically crystalline silica, has been associated with lung cancer in humans (IARC, 1997). Such an exposure is possible for Lompoc residents, especially those who work or have worked in the diatomaceous earth mining or processing industries which are present in the area (Checkoway et al., 1997).

Age-specific breakdown of the lung cancer incidence in Lompoc, as well as case-specific information on tobacco use or occupation, would prove useful in examining causality.

There is some limited evidence that the non-malignant respiratory diseases in adult residents of Lompoc could be associated with occupational exposures. Hospital discharges for asthma were significantly elevated in adults 25 years and older, rather than children. Additionally, seasonal variation did not appear to be a factor in the elevated respiratory diseases. This would suggest a relatively constant exposure, as might occur occupationally, but also could suggest a constant environmental factor. It is possible that exposure to cigarette smoke could explain the increase in asthma discharges, but most evidence links second-hand smoke to increased risks of asthma episodes in children rather than adults (OEHHA, 1997). Furthermore, hospital discharges for chronic obstructive pulmonary disease, which is associated with tobacco smoking (Snider et al., 1994), were lower than expected in Lompoc. This suggests a lower prevalence of smoking in adults residing in Lompoc. Allergens, such as fungal spores (Delfino et al., 1997), dust mites (Malveaux and Fletcher-Vincent, 1995), animal danders and molds (McFadden et al., 1991), and agricultural dust (Lang, 1996) also are potential causative agents. Nevertheless, without information on potential exposures, we can only speculate as to why respiratory illnesses appear to be elevated in Lompoc.

Lompoc residents have complained of many illnesses, but increased respiratory disease has been a repetitive theme. Bronchitis and asthma were identified by local residents as major concerns. As stated previously, the goal of this evaluation was to address which illnesses in the Lompoc area are occurring at a rate higher than would normally be expected. OEHHA was not able to address all of the health concerns of the Lompoc community. In many instances, usable health data were available only during certain years, and therefore, could not address current health status. For instance, hospital discharge rates were not calculated because a reliable population estimate for the years 1991 to 1994 for Lompoc were not readily available. OEHHA examined the possibility of calculating rates for 1990 hospital discharges because population data are available for that year. Unfortunately, the OSHPD hospital discharge database in 1990 did not include county codes, so we could not obtain hospital discharge estimates for the counties to which Lompoc was compared. The scope of readily accessible data was limited, and only addressed specific diseases (e.g., birth defects and cancer incidence), or severe illness (hospital discharges), but not symptoms, which have been a primary focus of community complaints. Furthermore, the geographic areas to which Lompoc was compared were limited. Nevertheless, this evaluation does provide some corroboration of the residents' concerns that respiratory illnesses are elevated in Lompoc.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

In light of the findings of respiratory disease excess, further investigation is warranted. This investigation should emphasize the most appropriate measures of disease, such as disease incidence (the development of new cases of disease on a per capita basis). Further, additional investigation should focus on a wider range of illness severity, ranging from symptoms on the one hand to mortality on the other hand. Where possible, primary data should be collected, including the personal histories of residents, occupational exposures, and other pertinent exposures, such as tobacco use. In the search for causes or explanations of the elevated respiratory disease, environmental correlates of residence in Lompoc, such as meteorological conditions, seasonal differences, and ambient environmental contaminants (including pesticides, air pollutants and toxicants, diatomaceous earth, and allergens, such as dusts, pollens, fungi, or molds) should be investigated.

Note to readers: As this report was being finalized, OEHHA received the OSHPD "confidential" data base, which contains record linkage numbers allowing an assessment of the number of people discharged from hospitals (as opposed to simply the number of hospital discharges), as well as additional detail regarding the discharges. This new data set will allow OEHHA to address some of the issues raised by both scientific reviewers and community residents in a subsequent extended analysis of the hospital discharge data.

REFERENCES

Akers, P; Wilhoit, L; Broome, J; Hobza, R; Teso, R; Supkoff, D (1995). An inventory of pest management practices in the Lompoc Valley. Second edition. Pest Management Analysis and Planning Program, Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, California. August 1995.

[ACS] American Cancer Society (1993). California cancer facts and figures, 1994. American Cancer Society, California Division. Oakland, California.

[ACS] American Cancer Society (1997). California facts and figures, 1998. American Cancer Society, California Division, and Public Health Institute, California Cancer Registry. Oakland, CA. September 1997.

Ames, RG (1996). Epidemiology: general principles, methodological issues, and applications to environmental toxicology. In: Fan, AM and Chang, LW, *Toxicology and Risk Assessment*. New York: Marcel Dekker. pp. 559-572.

Barthel, E (1981). Increased risk of lung cancer in pesticide-exposed male agricultural workers. *J. Toxicol. Environ. Health* 8, 1027-1040.

Blair, A; Grauman, DJ; Lubin, JH; Fraumeni, JF, Jr (1983). Lung cancer and other causes of death among licensed pesticide applicators. *J. Natl. Cancer Inst*. 71, 31-37.

Brown, L; Blair, A; Gibson, R; Everett, G; Cantor, K et al. (1990). Pesticide exposures and other agricultural risk factors for leukemia among men in Iowa and Minnesota. *Cancer Res*. 50, 6585-6591.

Brown, L; Burmeister, L; Everett, G; Blair, A (1993). Pesticide exposures and multiple myeloma in Iowa men. *Cancer Causes Control* 4, 153-156.

[CBDMP] California Birth Defects Monitoring Program (1996). Birth defects in Lompoc. September 1996.

Cantor, K; Blair, A; Everett, G; Gibson, R; Burmeister, L et al. (1992). Pesticides and other agricultural risk factors in non-Hodgkin's lymphoma among men in Iowa and Minnesota. *Cancer Res*. 52, 2447-2455.

[CDC] U.S. Centers for Disease Control (1992). Asthma--United States, 1980-1990. *Morbid. Mortal. Week. Rep*. 41, 733-735.

[CDC] U.S. Centers for Disease Control (1994). Microcomputer program Epi Info 6, version 6.02.

[CDC] U.S. Centers for Disease Control (1995). Asthma--United States, 1982-1992. *Morbid. Mortal. Week. Rep*. 43, 952.

Checkoway, H; Heyer, NJ; Demers, PA; Breslow, NE (1993). Mortality among workers in the diatomaceous earth industry. *Br. J. Industr. Med*. 50, 586-597.

Checkoway, H; Heyer, NJ; Seixas, NS; Welp, EAE; Demers. PA; Hughes, JM; Weill, H (1997). Dose-response associations of silica with nonmalignant respiratory disease and lung cancer mortality in the diatomaceous earth industry. *Am. J. Epidemiol*. 145, 680-688.

Churg, A (1994). Lung cancer cell type and occupational exposure. In: Samet, J (ed.), *Epidemiology of Lung Cancer*. New York: Marcel Dekker, Inc. pp. 413-436.

Delfino, RJ; Zeiger, RS; Seltzer, JM; Street, DH; Matteucci, RM; Anderson, PR; Koutrakis, P (1997). The effect of outdoor fungal spore concentrations on daily asthma severity. *Environ. Health Perspect*. 105, 622-635.

[DPR] California Department of Pesticide Regulation (1996). Update on Lompoc. August 1996. 13 pp.

Ernster, VL; Mustacchi, P; Osann, KE (1994). Epidemiology of lung cancer. In: Murray, JF; Nadel, JA (eds.), *Textbook of Respiratory Medicine*, 2nd ed. Philadelphia: W.B. Saunders Company. pp. 1504-1527.

Evans, R, III; Gergen, PJ (1996). Epidemiology of allergy and asthma. In: Bierman, CW; Pearlman, DS; Shapiro, GG; Busse, WW (eds.), *Allergy, Asthma, and Immunology from Infancy to Adulthood*, 3rd ed. Philadelphia: W.B. Saunders Company. pp. 79-92.

Gergen, PJ; Weiss, KB (1992). The increasing problem of asthma in the United States. *Am. Rev. Respir. Dis*. 146, 823-824 (editorial).

Goldsmith, DF (1994). Silica exposure and pulmonary cancer. In: Samet, J (ed.), *Epidemiology of Lung Cancer*. New York: Marcel Dekker, Inc. pp. 245-298.

Hennekens, CH; Buring, JE (1987). *Epidemiology in Medicine*. Boston: Little Brown and Co.

Hervis, RM (1993). Impact of DRGs on the medical profession. *Clin. Lab. Sci*. 6(3), 183-185.

Hickson, DE (1987). The role of fire and soil in the dynamics of Burton Mesa chaparral. Dissertation: The University of California, Santa Barbara.

[IARC] International Agency for Research on Cancer (1997). Silica, some silicates, coal dust, and para-aramid fibrils. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 68. Lyon, France: International Agency for Research on Cancer.

[IRIS] Integrated Risk Information Systems (1995). Arsenic, inorganic. Carcinogenicity assessment last revised 7-1-95.

Jensen, OM; Parkin, DM; MacLennan, R; Muir, CS; Skeet, RG (1991). Cancer registration: principles and methods. IARC Scientific Publication No. 95. Lyon, France: International Agency for Research on Cancer. pp. 155-158.

Johnson, B (1997). Complete pesticide use report for Lompoc. Electronic mail from Bruce Johnson to the Lompoc Interagency Workgroup Exposure Subcommittee, October 16, 1997.

Lang, L (1996). Danger in the dust. *Environ. Health Perspect*. 104, 26-30.

Last, JM; Abramson, JH (1995). *A Dictionary of Epidemiology*. 3rd Ed. Oxford University Press.

Mabuchi, K; Lilienfeld, AM; Snell, LM (1979). Lung cancer among pesticide workers exposed to inorganic arsenicals. *Arch. Environ. Health* 34, 312-320.

Malveaux, FJ; Fletcher-Vincent, SA (1995). Environmental risk factors of childhood asthma in urban centers. *Environ. Health Perspect*. 103(Suppl. 6), 59-62.

Maroni, M; Fait, A (1993). Health effects in man from long-term exposure to pesticides. A review of the 1975-1991 literature. *Toxicology* 78, 1-180.

McFadden, Jr, ER (1991). Asthma. In: Wilson, JD; Braunwald, E; Isselbacher, KJ et al. (eds.), *Harrison's Principles of Internal Medicine,* 12th ed., vol. 2. New York: McGraw-Hill, Inc. pp. 1047-1053.

Miettinen, OS; Wang, J (1981). An alternative to the proportionate mortality ratio. *Am. J. Epidemiol*. 114, 144-148.

Monson, RR (1980). *Occupational Epidemiology*. Boca Raton, FL: CRC Press. pp. 86-91.

Morrison, DF (1967). *Multivariate Statistical Methods*. New York: McGraw-Hill Book Company. pp. 130-133.

Namboodiri, NK; Carter, LF; Blalock, Jr, HM (1975). *Applied Multivariate Analysis and Experimental Designs*. New York: McGraw-Hill. pp 234-238.

[OEHHA] Office of Environmental Health Hazard Assessment (1997). Health effects of exposure to environmental tobacco smoke. Final Report. Sacramento, California. September 1997.

[OSHPD] Office of Statewide Health Planning and Development (1993). 1992 Discharge data tape format documentation. June 1993.

Pearce, N; Reif, J (1990). Epidemiologic studies of cancer in agricultural workers. *Am. J. Indust. Med*. 18, 133-138.

[PETS] Pesticide and Environmental Toxicology Section (1997). Analysis protocol. Analysis of hospital discharge data: Lompoc vs. Santa Barbara County, San Luis Obispo County, and two upper coast counties, 1991-1994. Pesticide and Environmental Toxicology Section, Office of Environmental Health Hazard Assessment. June 1, 1997.

Philbrick R; Odion, D (1988). Analyses of preserve sites for Burton Mesa chaparral. Santa Barbara County: Resource Management Department.

Snider, GL; Faling, LJ; Rennard, SI (1994). Chronic bronchitis and emphysema. In: Murray, JF and Nadel, JA (eds.), *Textbook of Respiratory Medicine*, 2nd ed. Philadelphia: W.B. Saunders Company. pp. 1331-1397.

Stierman, L (1994). Birth defects in California: 1983-1990. California Birth Defects Monitoring Program. December 1994.

Weisenburger, D (1990). Environmental epidemiology of non-Hodgkin's lymphoma in eastern Nebraska. *Am. J. Indust. Med*. 18, 303-305.

Zahm, S; Weisenburger, D; Babbitt, P; Saal, R; Vaught, J et al. (1990). A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in eastern Nebraska. *Epidemiology* 1, 349-356.